CHAPTER 13

RIGGING

Rigging is a technique of handling materials using wire rope, fiber rope, chains, slings, spreader bars, and so forth. Rigging is a vital link in the weight-handling process.

In the Naval Construction Force (NCF), an in-depth management program for maintenance and use of all rigging gear is required to ensure the entire weight-handling operations are performed safely and professionally. These guidelines are outlined in the COMSECOND/COMTHIRDNCBINST 11200.11, *Use of Wire Rope Slings and Rigging Hardware in the Naval Construction Force.*

This chapter covers the characteristics, maintenance, usage, and storage of rigging gear used in weight-handling operations.

WIRE ROPE

Many of the movable components on cranes and attachments are moved by wire rope. Wire rope is a complex machine, composed of a number of precise, moving parts. The moving parts of wire rope are designed and manufactured to bear a definite relationship to one another to have the necessary flexibility during operation.

Wire rope may be manufactured by either of two methods. If the strands, or wires, are shaped to conform to the curvature of the finished rope before laying up, the rope is termed **preformed wire rope.** If they are not shaped before fabrication, the wire rope is termed **non-preformed wire rope.**

The most common type of manufactured wire rope is preformed. When cut, the wire rope tends not to unlay and is more flexible than non-preformed wire rope. With non-preformed wire rope, twisting produces a stress in the wires; therefore, when it is cut or broken, the stress causes the strands to unlay.

NOTE: When the wire is cut or broken, the almost instantaneous unlaying of the wires and strands of non-preformed wire rope can cause serious injury to someone that is careless or not familiar with this characteristic of the rope.

PARTS OF WIRE ROPE

Wire rope is composed of three parts: **wires, strands,** and **core** (fig. 13- 1). A predetermined number of wires of the same or different size are fabricated in a uniform arrangement of definite lay to form a strand. The required number of strands are then laid together symmetrically around the core to form the wire rope.

Wire

The basic component of the wire rope is the wire. The wire may be made of steel, iron, or other metal in various sizes. The number of wires to a strand varies, depending on the purpose for which the wire rope is intended. Wire rope is designated by the number of strands per rope and the number of wires per strand. Thus an 1/2-inch 6 x 19 rope has six strands with 19 wires per strand. It has the same outside diameter as a 1/2-inch 6 x 37 rope that has six strands with 37 wires (of smaller size) per strand.

Strand

The design arrangement of a strand is called the construction. The wires in the strand maybe all the same size or a mixture of sizes. The most common strand

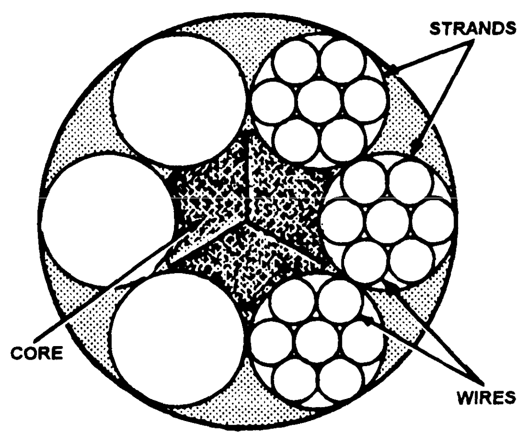

Figure 13-1.—Parts of wire rope.

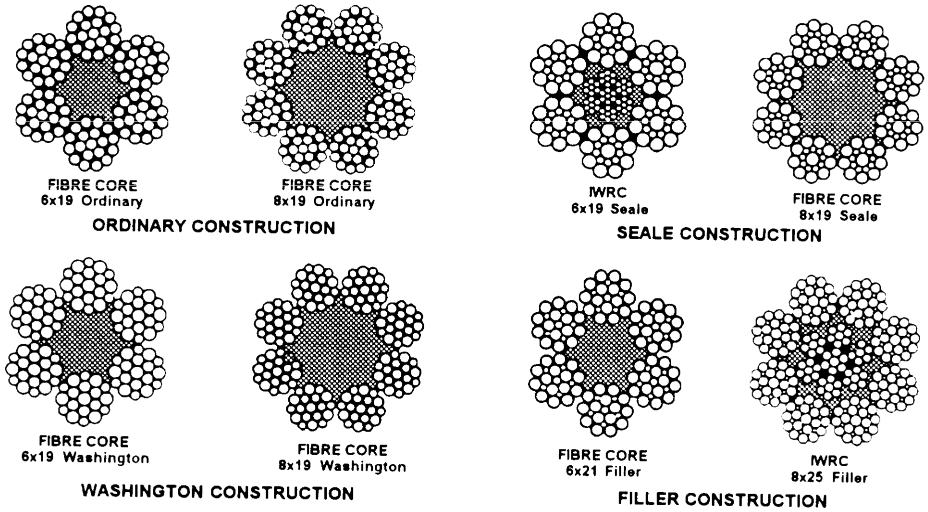

Figure 13-2.—Common strand construction.

constructions are Ordinary, Seale, Warrington, and Filler (fig. 13-2).

- **Ordinary** construction wires are all the same size.

- **Seale** is where larger diameter wires are used on the outside of the strand to resist abrasion and smaller wires are inside to provide flexibility.

- **Warrington** is where alternate wires are large and small to combine great flexibility with resistance to abrasion.

- **Filler** is where very small wires fill in the valleys between the outer and inner rows of wires to provide good abrasion and fatigue resistance.

Core

The wire rope core supports the strands laid around it. The three types of wire rope cores arc fiber, wire strand, and independent wire rope (fig. 13-3).

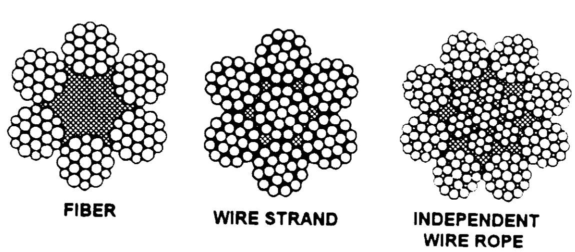

Figure 13-3.—Core construction.

- A **fiber core** may be a hard fiber, such as manila, hemp, plastic, paper, or sisal. The fiber core offers the advantage of increased flexibility. It also serves as a cushion to reduce the effects of sudden strain and acts as an oil reservoir to lubricate the wire and strands (to reduce friction). Wire rope with a fiber core is used when flexibility of (he rope is important.

- A **wire strand core** resists more heat than a fiber core and also adds about 15 percent to the strength of the rope; however, the wire strand core makes the wire rope less flexible than a fiber core.

- An **independent wire rope core** is a separate wire rope over which the main strands of the rope are laid. This core strengthens the rope, provides support against crushing, and supplies maximum resistance to heat.

GRADES OF WIRE ROPE

The three primary grades of wire rope are mild plow steel, plow steel, and improved plow steel.

Mild Plow Steel Wire Rope

Mild plow steel wire rope is tough and pliable. It can stand repeated strain and stress and has a tensile strength (resistance to lengthwise stress) of from 200,000 to 220,000 pounds per square inch (psi). These characteristics make it desirable for cable tool drilling and other purposes where abrasion is encountered.

Plow Steel Wire Rope

Plow steel wire rope is unusually tough and strong. This steel has a tensile strength of 220,000 to 240,000 psi. Plow steel wire rope is suitable for hauling, hoisting, and logging.

Improved Plow Steel Wire Rope

Improved plow steel wire rope is one of the best grades of rope available and is the most common rope used in the NCF. This type of rope is stronger, tougher, and more resistant to wear than either mild plow steel or plow steel. Each square inch of improved plow steel can stand a strain of 240,000 to 260,000 pounds. This makes it especially useful for heavy-duty service, such as on cranes with excavating and weight-handling attachments.

LAYS OF WIRE ROPE

The term **lay** refers to the direction of the twist of the wires in a strand and to the direction that the strands are laid in the rope. In some instances, both the wires in the strand and the strands in the rope are laid in the same direction; and in other instances, the wires are laid in one direction and the strands are laid in the opposite direction, depending on the intended use of the rope. Most manufacturers specify the types and lays of wire rope to be used on their piece of equipment. Be sure and consult the operator's manual for proper application.

Five different lays of wire rope are shown in figure 13-4.

The five types of lays used in wire rope are as follows:

- **Right Regular Lay:** In right regular lay rope, the wires in the strands are laid to the left, while the strands are laid to the right to form the wire rope.

- **Left Regular Lay:** In left regular lay rope, the wires in the strands are laid to the right, while the strands are laid to the left to form the wire rope. In this lay, each step of fabrication is exactly opposite from the right regular lay.

- **Right Lang Lay:** In right lang lay rope, the wires in the strands and the strands in the rope are laid in the same direction; in this instance, the lay is to the right.

- **Left Lang Lay:** In left lang lay rope, the wires in the strands and the strands in the rope are also laid in the same direction; in this instance, the lay is to the left (rather than to the right as in the right lang lay).

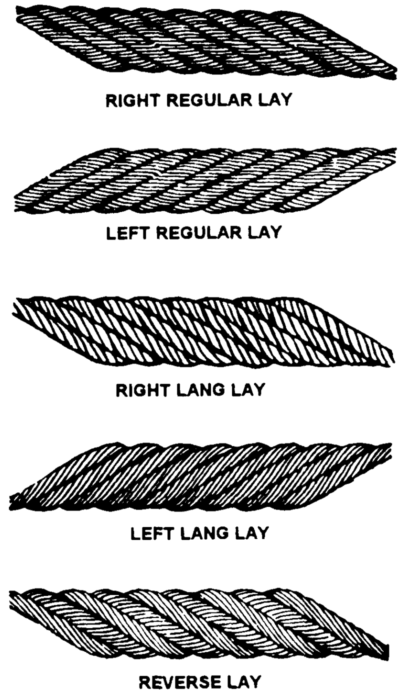

Figure 13-4.—Lays of wire rope.

- **Reverse Lay:** In reverse lay rope, the wires in one strand are laid to the right, the wires in the nearby strand are laid to the left, the wires in the next strand are to the right, and so forth, with alternate directions from one strand to the other. Then all strands are laid to the right.

LAY LENGTH OF WIRE ROPE

The length of a rope lay is the distance measured parallel to the center line of a wire rope in which a strand makes one complete spiral or turn around the rope. The length of a strand lay is the distance measured parallel to the center line of the strand in which one wire makes one complete spiral or turnaround the strand. Lay length measurement is shown in figure 13-5.

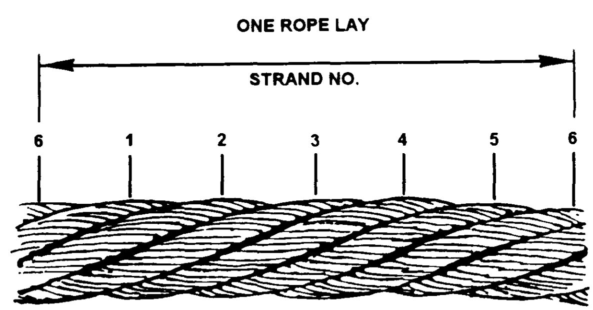

Figure 13-5.—Lay length of wire rope.

CHARACTERISTICS OF WIRE ROPE

The main types of wire rope used by the NCF consist of 6, 7, 12, 19, 24, or 37 wires in each strand. Usually, the wire rope has six strands laid around the core.

The two most common types of wire rope, 6 X 19 and 6 x 37, are shown in figure 13-6. The 6 x 19 type (having six strands with 19 wires in each strand) is the stiffest and strongest construction of the types of wire rope suitable for general hoisting operations. The 6 x 37 wire rope (six strands with 37 wires in each strand) is very flexible, making it suitable for cranes and similar equipment where sheaves are smaller than usual. The wires in the 6 x 37 are smaller than the wires in the 6 x 19 wire rope and, consequently, will not stand as much abrasive wear.

Several factors must be considered whenever a wire rope is selected for use in a particular kind of operation. The manufacture of a wire rope which can withstand equally well all kinds of wear and stress, it may be subjected to, is not possible, Because of this, selecting a rope is often a matter of compromise, sacrificing one quality to have some other more urgently needed characteristic.

Tensile Strength

Tensile strength is the strength necessary to withstand a certain maximum load applied to the rope. It includes a reserve of strength measured in a so-called factor of safety.

Crushing Strength

Crushing strength is the strength necessary to resist the compressive and squeezing forces that distort the cross section of a wire rope, as it runs over sheaves, rollers, and hoist drums when under a heavy load. Regular lay rope distorts less in these situations than lang lay.

Fatigue Resistance

Fatigue resistance is the ability to withstand the constant bending and flexing of wire rope that runs continuously on sheaves and hoist drums. Fatigue resistance is important when the wire rope must run at high speeds. Such constant and rapid bending of the rope can break individual wires in the strands. Lang lay ropes are best for service requiring high fatigue resistance. Ropes with smaller wires around the outside of their strands also have greater fatigue resistance, since these strands are more flexible.

Abrasion Resistance

Abrasion resistance is the ability to withstand the gradual wearing away of the outer metal, as the rope runs across sheaves and hoist drums. The rate of abrasion depends mainly on the load carried by the rope and its running speed. Generally, abrasion resistance in a rope depends on the type of metal of which the rope is made and the size of the individual outer wires. Wire rope made of the harder steels, such as improved plow steel, have considerable resistance to abrasion. Ropes that have larger wires forming the outside of their strands are more resistant to wear than ropes having smaller wires which wear away more quickly.

Corrosion Resistance

Corrosion resistance is the ability to withstand the dissolution of the wire metal that results from chemical attack by moisture in the atmosphere or elsewhere in the working environment. Ropes that are put to static work, such as guy wires, may be protected from corrosive elements by paint or other special dressings. Wire rope may also be galvanized for corrosion protection. Most wire ropes used in crane operations must rely on their lubricating dressing to double as a corrosion preventive.

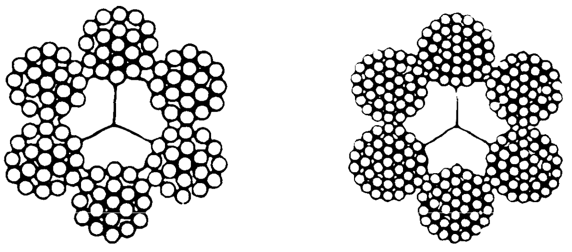

Figure 13-6.-A. 6 x 19 wire rope; B. 6 x 37 wire rope.

MEASURING WIRE ROPE

Wire rope is designated by its diameter in inches, as shown in figure 13-7. The correct method of measuring the wire rope is to measure from the top of one strand to the top of the strand directly opposite it. The wrong way is to measure across two strands side by side.

To ensure an accurate measurement of the diameter of a wire rope, always measure the rope at three places,

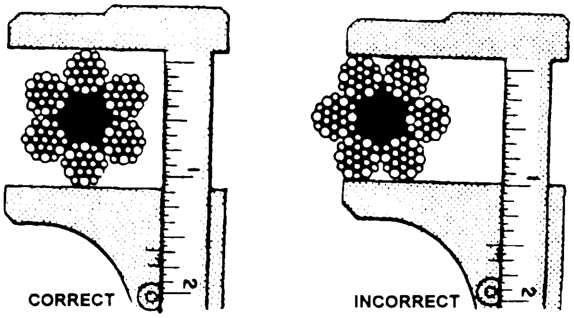

Figure 13-7.-Correct and incorrect methods of measuring wire rope.

at least 5 feet apart. Use the average of the three measurements as the diameter of the rope.

NOTE: A crescent wrench can be used as an expedient means to measure wire rope.

WIRE ROPE SAFE WORKING LOAD

The term *safe working load* (SWL) of wire rope means the load that can be applied and still obtain the most efficient service and also prolong the life of the rope.

The formula for computing the SWL of a wire rope is the diameter of the rope squared, multiplied by 8 (D x D x 8 = SWL in tons).

Example: The wire rope is 1/2 inch in diameter. Compute the SWL for the rope.

The first step is to convert the 1/2 into decimal number by dividing the bottom number of the fraction into the top number of the fraction: (1 divided by 2 = .5). Next, compute the SWL formula: (.5 x .5 x 8 = 2 tons). The SWL of the 1/2-inch wire rope is 2 tons.

NOTE: Do NOT downgrade the SWL of wire rope due to being old, worn, or in poor condition. Wire rope in these conditions should be cut up and discarded.

WIRE ROPE FAILURE

Some of the common causes of wire rope failure are the following:

- Using incorrect size, construction, or grade
- Dragging over obstacles
- Lubricating improperly
- Operating over sheaves and drums of inadequate size
- Overriding or crosr winding on drums
- Operating over sheaves and drums with improperly fitted grooves or broken flanges
- Jumping off sheaves
- Exposing to acid or corrosive liquids or gases
- Using an improperly attached fitting
- Allowing grit to penetrate between the strands, promoting internal wear
- Subjecting to severe or continuing overload
- Using an excessive fleet angle

HANDLING AND CARE OF WIRE ROPE

To render safe, dependable service over a maximum period of time, you should take good care and upkeep that is necessary to keep the wire rope in good condition. Various ways of caring for and handling wire rope are listed below.

Coiling and Uncoiling

Once a new reel has been opened, it maybe coiled or faked down, like line, The proper direction of coiling is **counterclockwise** for **left lay** wire rope and **clockwise** for **right lay** wire rope. Because of the general toughness and resilience of wire, it tends now and then to resist being coiled down. When this occurs, it is useless to fight the wire by forcing down the turn because it will only spring up again. But if it is thrown in a back turn, as shown in figure 13-8, it will lie down properly. A wire rope, when faked down, will run right

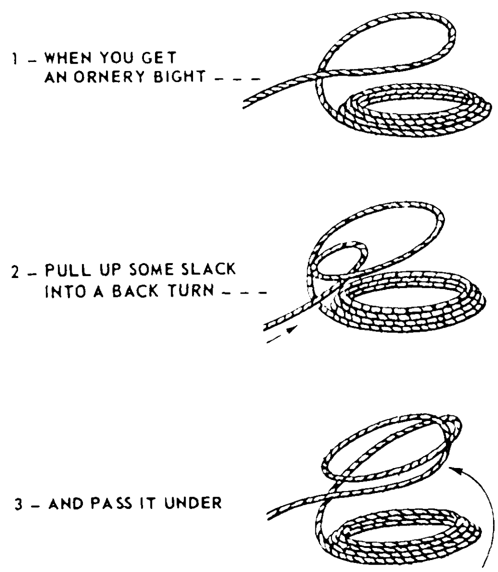

Figure 13-8.—Throwing a back turn.

off, like line; but when wound in a coil, it must always be unwound.

Wire rope tends to kink during uncoiling or unreeling, especially if it has been in service long. A kink can cause a weak spot in the rope that wears out quicker than the rest of the rope.

A good method for unreeling wire rope is to run a pipe, or rod, through the center and mount the reel on drum jacks or other supports so the reel is off the ground, as shown in figure 13-9. In this way, the reel will turn as the rope is unwound, and the rotation of the reel helps keep the rope straight. During unreeling, pull the rope straight forward, and avoid hurrying the operation. As a safeguard against kinking, NEVER unreel wire rope from a reel that is stationary.

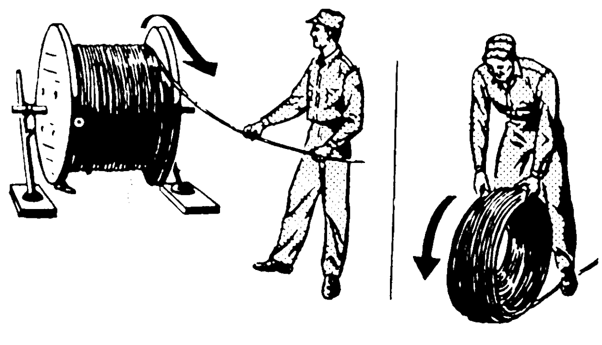

Figure 13-9.-Unreeling wire rope (left); uncoiling wire rope (right).

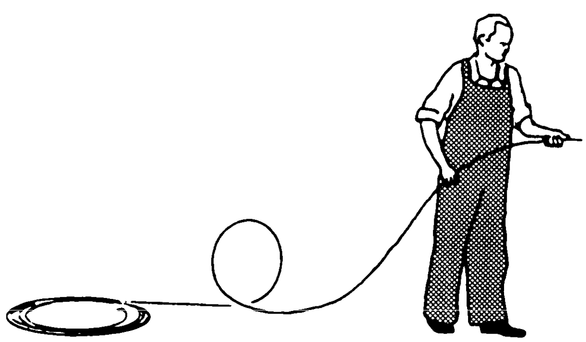

Figure 13-10.—Improper handling.

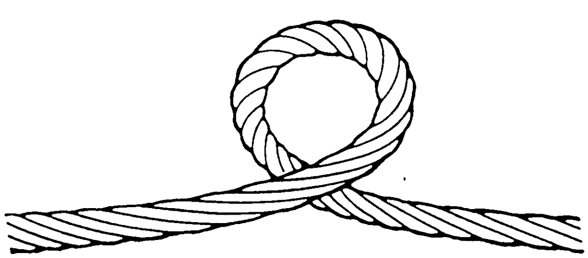

Figure 13-11.—Wire rope loop.

To uncoil a small coil of wire rope, simply stand the coil on edge and roll it along the ground like a wheel, or hoop, as also shown in figure 13-9. NEVER lay the coil flat on the floor or ground and uncoil it by pulling on the end, because such practice can kink or twist the rope.

Kinks

One of the most common forms of damage resulting from improper handled wire rope is the development of a kink. A kink starts with the formation of a loop, as shown in figures 13-10 and 13-11.

A loop that has not been pulled tight enough to set the wires or strands of the rope into a kink can be removed by turning the rope at either end in the proper direction to restore the lay, as shown in figure 13-12. If this is not done and the loop is pulled tight enough to cause a kink (fig. 13-13), the kink will result in irreparable damage to the rope (fig. 13-14).

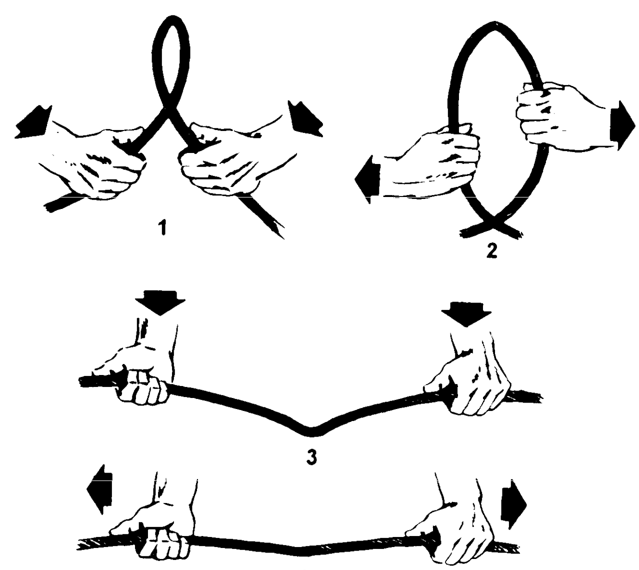

Figure 13-12.—The correct way to take out a loop in a wire rope.

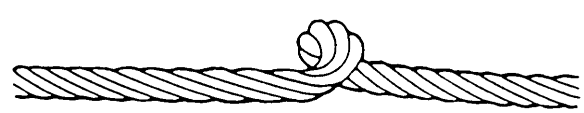

Figure 13-13.—Wire rope kink.

Figure 13-14.—Kink damage.

Kinking can be prevented by proper uncoiling and unreeling methods and by the correct handling of the rope throughout its installation.

Drum Winding

Spooling wire rope on a crane hoist drum causes a slight rotating tendency of the rope due to the spiral lay of the strands. Two types of hoist drums used for spooling wire rope are as follows:

1. Grooved drum. When grooved drums are used, the grooves generally give sufficient control to wind the wire rope properly, whether it is right or left lay rope.

2, Smooth-faced drum. When smooth-faced drums are used, where the only other influence on the wire rope in winding on the first layer is the fleet angle, the slight rotational tendency of the rope can be used as an advantage in keeping the winding tight and uniform.

NOTE: Using the wrong type of wire rope lay causes the rotational tendency of the rope to be a disadvantage, because it results in loose and nonuniform winding of the rope on the hoist drum.

Figure 13-15 shows drum winding diagrams for selection of the proper lay of rope. Standing behind the hoist drum and looking toward an oncoming overwind rope, the rotating tendency of right lay rope is toward the left; whereas, the rotating tendency of a left lay rope is toward the right.

Refer to figure 13-15. With overwind reeving and a right lay rope on a smooth-faced drum, the wire rope bitter end attachment to the drum flange should be at the left flange. With underwind reeving and a right lay rope, the wire rope bitter end attachment should beat the right flange.

When wire rope is run off one reel onto another or onto a winch or drum, it should be run from **TOP TO**

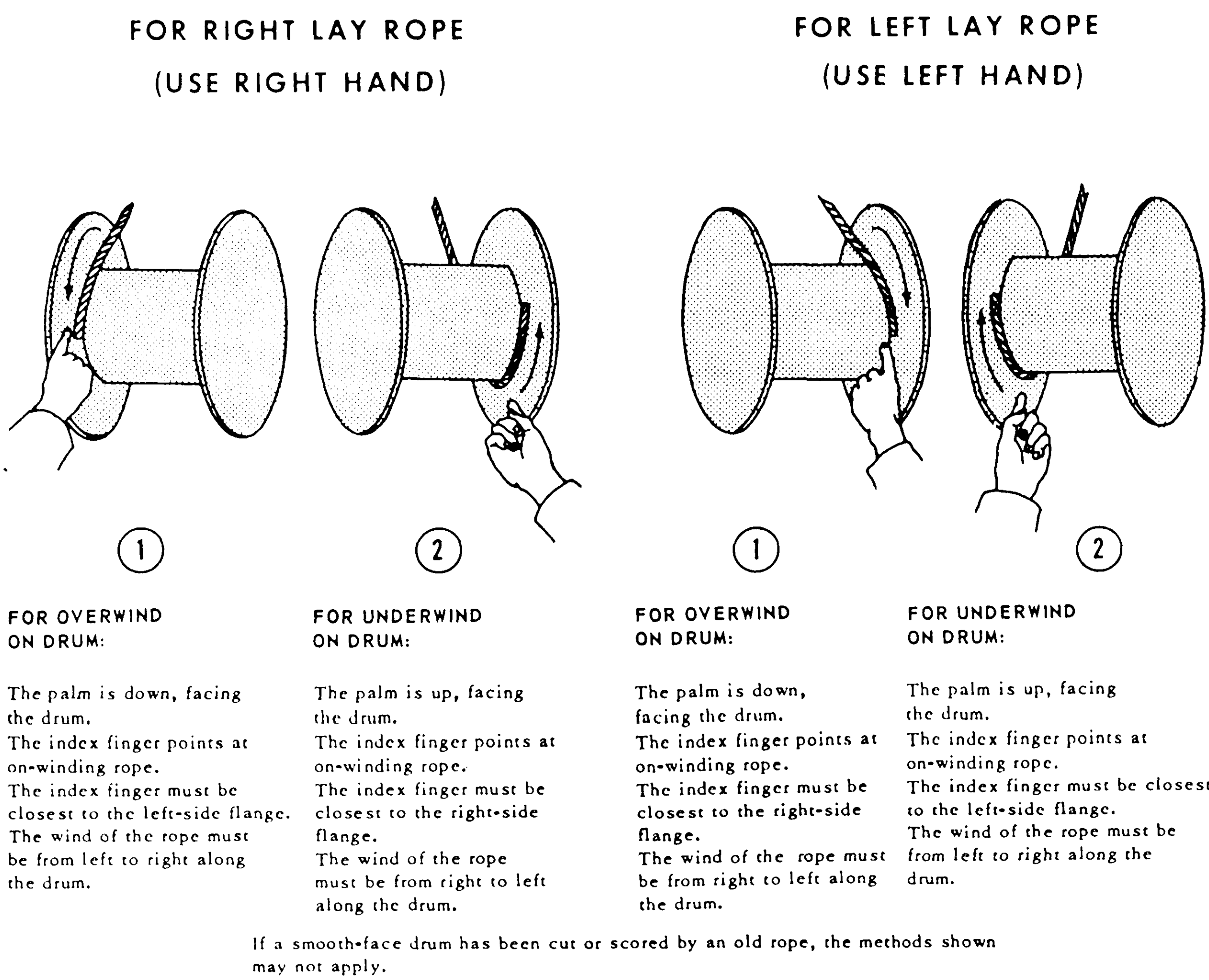

Figure 13-15.—Different lays of wire rope winding on hoist drums.

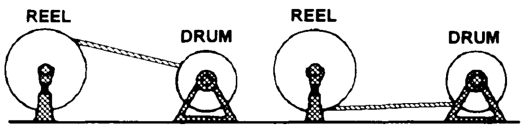

Figure 13-16.-Transferring wire rope from reel to drum.

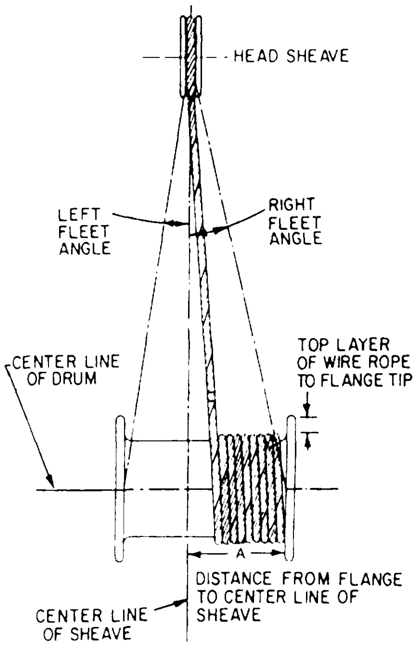

Figure 13-17.—Fleet angle relationship.

TOP or from **BOTTOM TO BOTTOM,** as shown in figure 13-16.

Fleet Angle

The fleet angle is formed by running wire rope between a sheave and a hoist drum whose axles are parallel to each other, as shown in figure 13-17. Too large a fleet angle can cause the wire rope to climb the flange of the sheave and can also cause the wire rope to climb over itself on the hoist drum.

Sizes of Sheaves

The diameter of a sheave should never be less than 20 times the diameter of the wire rope. An exception is 6 x 37 wire for which a smaller sheave can be used, because this wire rope is more flexible.

The chart shown in table 13-1 can be used to determine the minimum sheave diameter for wire rope of various diameters and construction.

Reverse Bends

Whenever possible, drums, sheaves, and blocks used with wire rope should be placed to avoid reverse or S-shaped bends. Reverse bends cause the individual wires or strands to shift too much and increase wear and fatigue. For a reverse bend, the drums and blocks affecting the reversal should be of a larger diameter than

Table 13-1.–Suggested Minimum Tread Diameter of Sheaves and Drums

Rope diameter in inches	Minimum tread diameter in inches for given rope construction*			
	6 x 7	6 x 19	6 x 37	8 x 19
1/4	10 1/2	8 1/2	---	6 1/2
3/8	15 3/4	12 3/4	6 3/4	9 3/4
1/2	21	17	9	13
5/8	26 1/4	21 1/4	11 1/4	16 1/4
3/4	31 1/2	25 1/2	13 1/2	19 1/2
7/8	36 3/4	29 3/4	15 3/4	22 3/4
1	42	34	18	26
1 1/8	47 1/4	38 1/4	20 1/2	29 1/4
1 1/4	52 1/2	42 1/2	22 1/2	32 1/2
1 1/2	63	51	27	39

Rope construction

Sheave diameter

*Rope construction is in strands times wires per strand.

ordinarily used and should be spaced as far apart as possible.

Seizing and Cutting

The makers of wire rope are careful to lay each wire in the strand and each strand in the rope under uniform tension. If the ends of the rope are not secured properly, the original balance of tension will be disturbed and maximum service cannot be obtained because some strands can carry a greater portion of the load than others. Before cutting steel wire rope, place seizing on each side of the point where the rope is to be cut (fig. 13-18).

A rule of thumb for determining the size, number, and distance between seizing is as follows:

1. The number of seizing to be applied equals approximately three times the diameter of the rope.

Example: 3 x 3/4-inch-diameter rope = 2 1/4 inches. Round up to the next higher whole number and use three seizing.

2. The width of each seizing should be 1 to 1 1/2 times as long as the diameter of the rope.

Example: 1 x 3/4-inch-diameter rope = 3/4 inch. Use a 1-inch width of seizing.

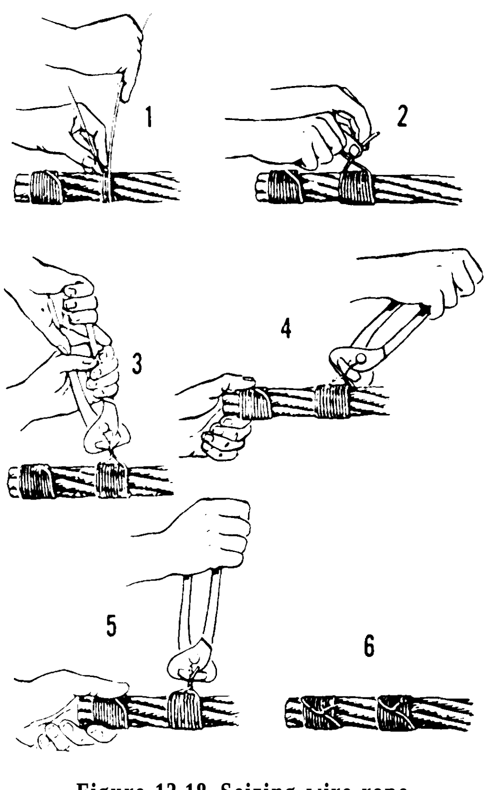

Figure 13-18.-Seizing wire rope.

3. The seizing should be spaced a distance equal to twice the diameter of the wire rope.

Example: 2 x 3/4-inch-diameter rope = 1 1/2 inches. Space the seizing 2 inches apart.

A common method used to make a temporary wire rope seizing is as follows:

Wind on the seizing wire uniformly, using tension on the wire. After taking the required number of turns, as shown in step 1, twist the ends of the wires counterclockwise by hand, so the twisted portion of the wires is near the middle of the seizing, as shown in step 2. Grasp the ends with end-cutting nippers and twist up slack, as shown in step 3. Do not try to tighten the seizing by twisting. Draw up on the seizing, as shown in step 4. Again twist up the slack, using nippers, as shown in step 5. Repeat steps 4 and 5 if necessary. Cut ends and pound them down on the rope, as shown in step 6. If the seizing is to be permanent or if the rope is 1 5/8 inches or more in diameter, use a serving bar, or iron, to increase tension on the seizing wire when putting on the turns.

Wire rope can be cut successfully by a number of methods. One effective and simple method is to use a hydraulic type of wire rope cutter, as shown in figure 13-19. Remember that all wire should be seized before it is cut. For best results in using this method, place the rope in the cutter so the blade comes between the two central seizings. With the release valve closed, jack the blade against the rope at the location of the cut and continue to operate the cutter until the wire rope is cut.

MAINTENANCE OF WIRE ROPE

Wire rope bending around hoist drums and sheaves will wear like any other metal article, so lubrication is just as important to an operating wire rope as it is to any other piece of working machinery. For a wire rope to

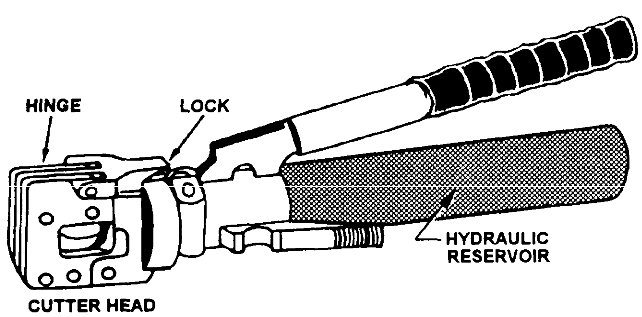

Figure 13-19.—Hydraulic type of wire rope cutter.

work right, its wires and strands must be free to move. Friction from corrosion or lack of lubrication shortens the service life of wire rope.

Deterioration from corrosion is more dangerous than that from wear, because corrosion ruins the inside wires—a process hard to detect by inspection. Deterioration caused by wear can be detected by examining the outside wires of the wire rope, because these wires become flattened and reduced in diameter as the wire rope wears.

NOTE: Replace wire rope that has wear of one third of the original diameter of the outside individual wires.

Both internal and external lubrication protects a wire rope against wear and corrosion. Internal lubrication can be properly applied only when the wire rope is being manufactured, and manufacturers customarily coat every wire with a rust-inhibiting lubricant, as it is laid into the strand. The core is also lubricated in manufacturing.

Lubrication that is applied in the field is designed not only to maintain surface lubrication but also to prevent the loss of the internal lubrication provided by the manufacturer. The Navy issues an asphaltic petroleum oil that must be heated before using. This lubricant is known as **Lubricating Oil for Chain, Wire Rope, and Exposed Gear** and comes in two types:

- Type I, Regular: Does not prevent rust and is used where rust prevention is not needed; for example, elevator wires used inside are not exposed to the weather but need lubrication.

- Type II, protective: A lubricant and an anti-corrosive— it comes in three grades: grade A, for cold weather (60°F and below); grade B, for warm weather (between 60°F and 80°F); and grade C, for hot weather (80°F and above).

The oil, issued in 25-pound and 35-pound buckets and in 100-pound drums, can be applied with a stiff brush, or the wire rope can be drawn through a trough of hot lubricant, as shown in figure 13-20. The frequency of application depends upon service conditions; as soon as the last coating has appreciably deteriorated, it should be renewed.

CAUTION

Avoid prolonged skin contact with oils and lubricants. Consult the Materials Safety Data Sheet (MSDS) on each item before use for precautions and hazards. See your supervisor for copies of MSDSs.

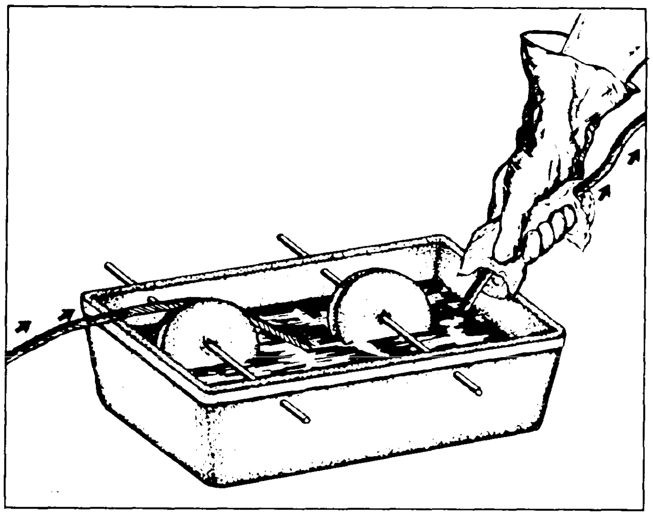

Figure 13-20.—Trough method of lubricating wire rope.

A good lubricant to use when working in the field, as recommended by COMSECOND/COMTHIRD-NCBINST 11200.11, is a mixture of new motor oil and diesel fuel at a ratio of 70-percent oil and 30-percent diesel fuel. The NAVFAC P-404 contains added information on additional lubricants that can be used.

Never lubricate wire rope that works a dragline or other attachments that normally bring the wire rope in contact with soils. The reason is that the lubricant will pick up fine particles of material, and the resulting abrasive action will be detrimental to both the wire rope and sheave.

As a safety precaution, always wipe off any excess oil when lubricating wire rope especially with hoisting equipment. Too much lubricant can get into brakes or clutches and cause them to fail. While in use, the motion of machinery may sling excess oil around over crane cabs and onto catwalks making them unsafe.

NOTE: Properly dispose of wiping rags and used or excess lubricant as hazardous waste. See your supervisor for details on local disposal requirements.

WIRE ROPE ATTACHMENTS

Many attachments can be fitted to the ends of wire rope, so the rope can be connected to other wire ropes, pad eyes, or equipment.

Wedge Socket

The attachment used most often to attach dead ends of wire ropes to pad eyes or like fittings on cranes and

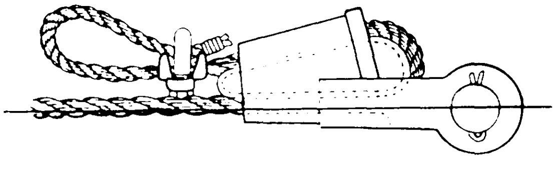

Figure 13-21.—Wedge socket.

earthmoving equipment is the wedge socket, as shown in figure 13-21. The socket is applied to the bitter end of the wire rope.

NOTE: The wedge socket develops only 70% of the breaking strength of the wire rope due to the crushing action of the wedge.

Speltered Socket

Speltering is the best way to attach a closed or open socket in the field. **"Speltering"** means to attach the socket to the wire rope by pouring hot zinc around it, as shown in figure 13-22. Speltering should only be done by qualified personnel.

Forged steel speltered sockets are as strong as the wire rope itself; they are required on all cranes used to lift personnel, ammunition, acids, and other dangerous materials.

NOTE: Spelter sockets develop 100% of the breaking strength of the wire rope.

Wire Rope Clips

Wire rope clips are used to make eyes in wire rope, as shown in figure 13-23. The U-shaped part of the clip with the threaded ends is called the **U-bolt;** the other part is called the **saddle.** The saddle is stamped with the diameter of the wire rope that the clip will fit. Always place a clip with the U-bolt on the bitter (dead) end, not on the standing part of the wire rope. If clips are attached incorrectly, the standing part (live end) of the wire rope will be distorted or have mashed spots. A rule of thumb when attaching a wire rope clip is to NEVER saddle a dead horse.

Two simple formulas for figuring the number of wire rope clips needed are as follows:

3 x wire rope diameter + 1 = Number of clips

6 x wire rope diameter = Spacing between clips

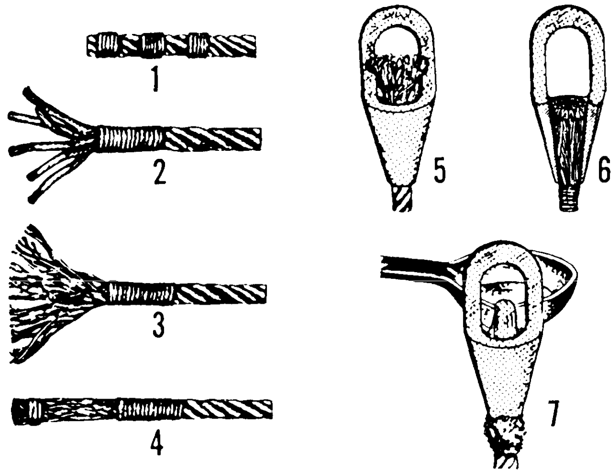

Figure 13-22.—Speltering a socket.

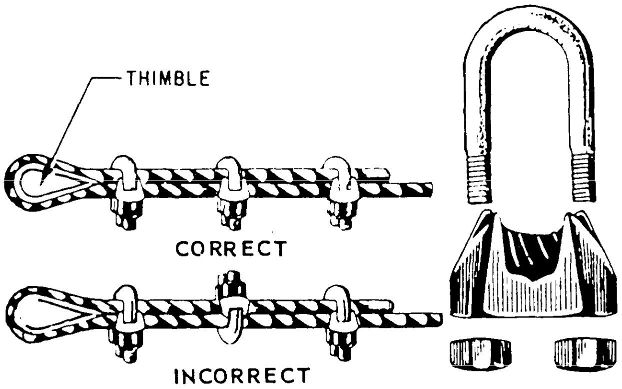

Figure 13-23.—Wire rope clips.

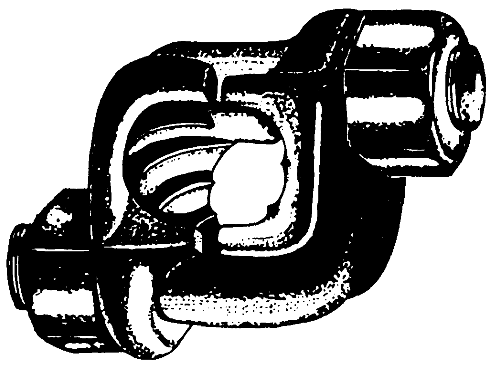

Figure 13-24.—Twin-base wire rope clip.

Another type of wire rope clip is the twin-base clip, often referred to as the universal or two clamp, as shown in figure 13-24. Both parts of this clip are shaped to fit the wire rope, so the clip cannot be attached incorrectly. The twin-base clip allows for a clear 360-degree swing with the wrench when the nuts are being tightened.

Thimble

When an eye is made in a wire rope, a metal fitting, called a **thimble,** is usually placed in the eye, as shown in figure 13-23. The thimble protects the eye against wear. Wire rope eyes with thimbles and wire rope clips can hold approximately 80 percent of the wire rope strength.

After the eye made with clips has been strained, the nuts on the clips must be retightened. Checks should be made now and then for tightness or damage to the rope caused by the clips.

Swaged Connections

Swaging makes an efficient and permanent attachment for wire rope, as shown in figure 13-25. A swaged connection is made by compressing a steel sleeve over the rope by using a hydraulic press. When the connection is made correctly, it provides 100-percent capacity of the wire rope.

Careful inspection of the wires leading into these connections are important because of the pressure put upon the wires in this section. If one broken wire is found at the swaged connection or a crack in the swage, replace the fitting.

Hooks and Shackles

Hooks and shackles are handy for hauling or lifting loads without tying them directly to the object with a line, wire rope, or chain. They can be attached to wire rope, fiber line, blocks, or chains. Shackles should be used for loads too heavy for hooks to handle.

When hooks fail due to overloading, they usually straighten out and lose or drop their load. When a hook has been bent by overloading, it should NOT be straightened and put back into service; it should be cut in half with a cutting torch and discarded.

Hooks should be inspected at the beginning of each workday and before lifting a full-rated load. If you are not sure a hook is strong enough to lift the load, by all means use a shackle.

Hooks that close and lock should be used where there is danger of catching on an obstruction, particularly in hoisting buckets, cages, or skips, and especially in shaft work. Hooks and rings used with a chain should have about the same strength as the chain.

The manufacturers' recommendations should be followed in determining the safe working loads of the various sizes and types of specific and identifiable hooks. All hooks for which no applicable manufacturers' recommendations tire available should be tested to twice the intended safe working load before they are initially put into use.

Mousing is a technique often used to close the open section of a hook to keep slings, straps, and similar attachments from slipping off the hook, as shown in figure 13-26.

Hooks may be moused with rope yarn, seizing wire, or a shackle. When using rope yarn or wire, make 8 or 10 wraps around both sides of the hook. To finish off, make several turns with the yarn or wire around the sides of the mousing, and then tie the ends securely.

Two types of shackles used in rigging are the **anchor** (Fig. 13-27) and the **chain** (fig. 13-28). Both are available with screw pins or round pins.

Shackles should be used in the same configuration as they were manufactured. Never replace the shackle pin with a bolt. when the original pin is lost or does not fit properly, do not use the shackle. All pins must be straight and cotter pins must be used or all screw pins must be seated.

A shackle should never be pulled from the side, because this causes the shackle to bend which reduces the capacity tremendously. Always attach a screw pin

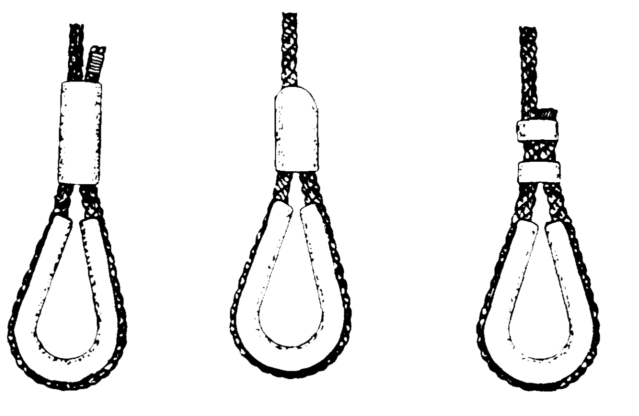

Figure 13-25.-Swaged connections.

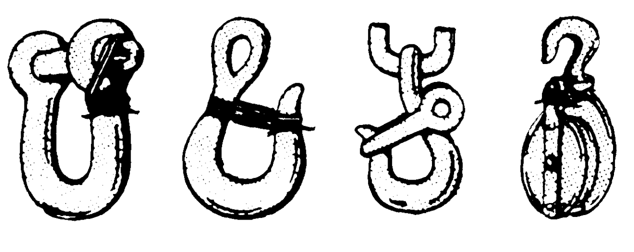

Figure 13-26.—Mousing.

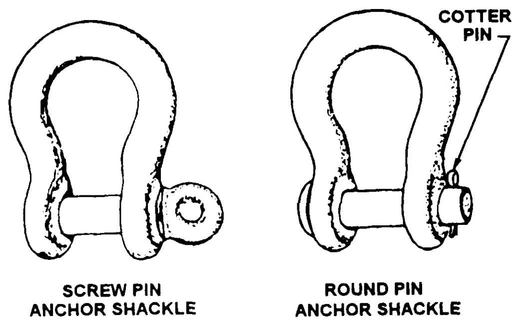

Figure 13-27.—Anchor shackles.

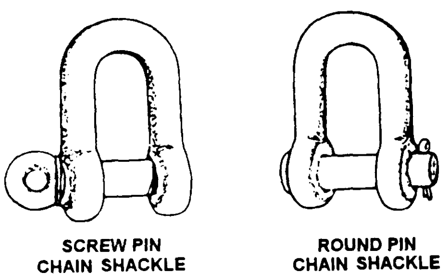

Figure 13-28.—Chain shackles.

shackle with the screw pin on the dead end of the rope. If placed on the running end, the movement of the rope may loosen the pin.

Shackles are moused whenever there is a chance of the shackle pin working loose and coming out because of vibration. To mouse a shackle, simply take several turns with seizing wire through the eye of the pin and around the bow of the shackle. Figure 13-26 shows what a properly moused shackle looks like.

FIBER LINE

Fiber line is commonly used to hoist and move heavy loads. Fiber line is constructed similar to wire rope. One difference is yarn. Yarn is used to make the strand in place of wire. Another difference is fiber line does not have a core.

TYPES OF FIBER LINE

The most common types of fiber line are manila, sisal, hemp, cotton, nylon, and Kevlar. The characteristics of these fiber lines are discussed below.

Manila

Manila is a strong fiber that comes from the leaf stems of the stalk of the abaca plant, which belongs to the banana family. The fibers vary in length from 1.2 to 4.5 meters in the natural state. The quality of the fiber and its length give manila rope relatively high elasticity, strength, and resistance to wear and deterioration. In many instances, the manufacturer treats the rope with chemicals to make it more mildew resistant, which increases the quality of the rope. Manila rope is generally the standard item of issue because of its quality and relative strength.

Sisal

Sisal rope is made from two tropical plants that yield a strong, valuable fiber. These plants, sisalana and henequen, produce fibers 0.6 to 1.2 meters long with sisalana producing the stronger fibers of the two plants. Because of the greater strength of sisalana, these fibers are used to make the rope known as sisal. Sisal rope is about 80 percent as strong as high-quality manila rope and can be easily obtained. It withstands exposure to seawater very well and is often used for this reason.

Hemp

Hemp is a tall plant that provides useful fibers for making rope and cloth. Cultivated in many parts of the world, hemp was used extensively before the introduction of manila. Its principal use now is in fittings, such as ratline, marline and spun yarn. Since hemp absorbs tar much better than the hard fibers, these fittings are invariably tarred to make them water resistant. Tarred hemp has about 80 percent of the strength of untarred hemp. Of these tarred fittings, marline is the standard item of issue.

Cotton

Cotton rope is a very smooth white rope that stands much bending and running. Cotton is not widely used in the Navy except in some cases for small lines.

Nylon

Nylon rope has a tensile strength that is nearly three times that of manila rope. The advantage of using nylon rope is that it is waterproof and has the ability to resume normal length after being stretched and/or absorbing shocks. It also resists abrasion, rot, decay, and fungus

When nylon rope is properly handled and maintained, it should last more than five times longer than manila line subjected to the same use. Nylon rope is also lighter, more flexible, less bulky, and easier to handle and store than manila line. When nylon rope is wet or frozen, it loses little strength. Additionally, nylon line defies mildew, rotting, and attack by marine borers.

Nylon rope can hold a load even when many strands are abraded. Normally, when abrasion is local, the rope may be restored to use by cutting away the chafed section and splicing the ends. Chafing, and stretching do not necessarily affect the load-carrying ability of nylon rope.

The splicing of nylon rope is very similar to that of manila; however, friction tape is used instead of seizing stuff for whipping the strands and line. Because it is smooth and elastic, nylon requires at least one tuck more than manila. For heavy loads, a back tuck should be taken with each strand.

As with manila, nylon rope is measured by circumference. Nylon, as manila, usually comes on a reel of 600 to 1,200 feet, depending upon the size. Do not uncoil new nylon rope by pulling the ends up through the eye of the coil. Unreel it as you would wire rope. Avoid coiling nylon in the same direction all the time, or you could unbalance the lay.

When nylon rope is stretched more than 40 percent, it is likely to part. The stretch is immediately recovered with a snapbaak that sounds like a pistol shot.

WARNING

The snapback of a nylon rope can be as deadly as a bullet. Make sure no one stands in the direct line of pull when a heavy strain is applied.

This feature is also true for other types of lines, but overconfidence in the strength of nylon may lead one to underestimate its backlash.

The critical point of loading is 40-percent extension of length; for example, a 10-foot length of nylon rope would stretch to 14 feet when under load. Should the stretch exceed 40 percent, the linc will be in danger of parting.

If a nylon rope becomes slippery because of grease, it should be cleaned with a light oil, such as kerosene or diesel oil.

Do not store nylon line in strong sunlight. Cover it with tarpaulins. In storage, keep it away from heat and strong chemicals.

Kevlar

Kevlar is most popularly used to make bulletproof vests and knifeproof gloves. The characteristics of Kevlar line are similar to those of Nylon line except for one significant difference—Kevlar line does not snapback when it parts. This is an important safety feature, since parted nylon line has resulted in numerous deaths due to violent snapbacks.

HANDLING AND CARE OF FIBER LINE

If you expect the fiber line you work with to give safe and dependable service, make sure it is handled and cared for properly. Procedures for handling and caring of fiber line arc as follows:

- CLEANLINESS is part of the care of fiber line. NEVER drag a line over the ground or over rough or dirty surfaces. The line can easily pickup sand and grit that can work into the strands and wear the fibers. If a line dots get dirty, use water only to clean it. **Do NOT** use soap, because it takes oil out of the line.

- AVOID pulling a line over sharp edges because the strands may break. When you have a sharp edge, place chafing gear, such as a board, folded cardboard or canvas, or part of a rubber tire, between the line and the sharp edge to prevent damaging the line.

- NEVER cut a line unless you have to. When possible, always use knots that can be untied easily.

Fiber line will contract or shrink if it gets wet. If there is not enough slack in a wet line to permit shrinkage, the line is likely to overstrain and weaken. If a taut line is exposed to rain or dampness, make sure that the line, while still dry, is slackened to allow for the shrinkage.

INSPECTION OF FIBER LINE

Line should be inspected carefully at regular intervals to determine if it is safe. The outside of a line does not show the condition of the line on the inside. Untwisting the strands slightly allows you to check the condition of the line on the inside. Mildewed line gives off a musty odor. Broken strands, or yarns, usually can be spotted immediately by a trained observer. You want to look carefully to ensure there is no dirt or sawdust-like materia] inside the line. Dirt or other foreign matter inside reveals possible damage to the internal structure of the line. A smaller circumference of the line is usually a sure sign that too much strain has been applied to the line.

For a thorough inspection, a line should be examined at several places. After all, only one weak spot, anywhere in a line, makes the entire line weak. As a final check, pull out a couple of fibers from the line and try to break them. **Sound fibers** have a strong

If an inspection discloses any unsatisfactory conditions in a line, see that the line is destroyed or cut into small pieces as soon as possible. This precaution prevents the defective line from being used for hoisting.

CHAIN

In the NCF, never use a chain when it is possible to use wire rope. The reason for this is because, unlike wire rope, chain does not have reserve strength and does not give any warning that it is about to fail; therefore, you will not be alerted of a potentially hazardous condition.

Chain is better suited than wire rope for some jobs because it is more resistant to abrasion, corrosion, and heat. When chain is used as a sling, it has no flexibility and grips the load well.

CHAIN GRADES

It is difficult to determine the grade of some types of chains by looking at them. Most chains used by the NCF are class A chain. If you are uncertain of the class or size of a chain, ask your supervisor.

CHAIN STRENGTH

Before lifting with a chain, make sure the chain is free from twists and kinks. A twisted or kinked chain placed under stress could fail even when handling a light load. Additionally, ensure that the load is properly seated in the hook (not on the point) and that the chain is free from nicks or other damage. Avoid sudden jerks in lifting and lowering the load, and always consider the angle of lift with a sling chain bridle.

The strength of any chain will be affected when it has been knotted, overloaded, or heated to temperatures above 500°F.

HANDLING AND CARE OF CHAIN

When hoisting heavy metal objects using chain for slings, you should insert padding around the sharp corners of the load to protect the chain links from being cut.

Store chains in a clean, dry place where they will not be exposed to the weather. Before storage, apply a light coat of lubricant to prevent rust.

Do NOT perform makeshift repairs, such as fastening links of a chain together with bolts or wire. When links become worn or damaged, cut them out of the chain, then fasten the two nearby links together with a connecting link. After the connecting link is closed, welding makes it as strong as the other links. For cutting small-sized chain links, use bolt cutters. To cut large-sized links, use a hacksaw.

Inspect the chain to ensure it is maintained in a safe, operating condition. A chain used continuously for heavy loading should be inspected frequently. Chain is less reliable than manila or wire rope slings because the links may crystallize and snap without warning.

Examine the chain closely link by link and look for stretch, wear, distortion, cracks, nicks, and gouges. Wear will usually be at the ends of the links where joining links rub together. If you find wear, lift each link and measure its cross section.

NOTE: Remove chains from service when any link shows wear more than 25 percent of the thickness of the metal.

Replace any link that shows cracks, distortion, nicks, or cuts; however, if a chain shows stretching or distortion of more than 5 percent in a five-link section, discard and destroy the entire chain.

Remove chains from service when links show any signs of binding at the juncture points of the links. This condition indicates collapse in the sides of the links has occurred as a result of stretching.

Before lifting with a chain, first place dunnage between the chain and the load to provide a gripping surface. For hoisting heavy metal objects with a chain, always use chafing gear around the sharp corners on the load to protect the chain links from being cut. As chafing gear, use either planks or heavy fabric. In handling rails or a number of lengths of pipe, make a round turn and place the hook around the chain, as shown in figure 13-29.

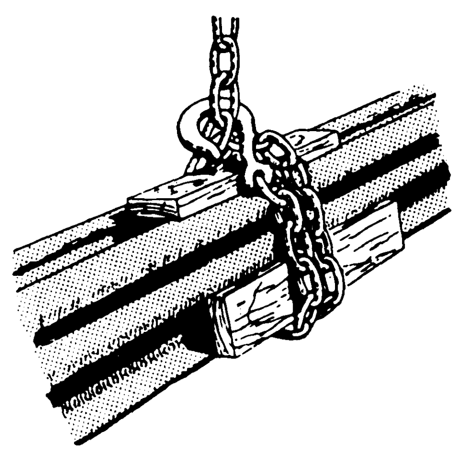

Figure 13-29.—Chain sling.

SLINGS

Slings are widely used for hoisting and moving heavy loads. Some types of slings come already made. Slings may be made of wire rope, fiber line, or chain.

SLINGS AND RIGGING GEAR KITS

The NCF has slings and rigging gear in the battalion Table of Allowance to support the rigging operations and the lifting of CESE. The kits 80104, 84003, and 84004 must remain in the custody of the supply officer in the central toolroom (CTR). The designated embarktion staff and the crane test director monitor the condition of the rigging gear. The crane crew supervisor normally has the responsibility to inventory the contents of the kits. The rigging kits must be stored undercover.

WIRE ROPE SLINGS

Wire rope slings offer advantantges of both strength and flexibility. These qualities make wire rope adequate to meet the requirements of most crane hoisting jobs; therefore, you will use wire rope slings more frequently than fiber line or chain slings.

FIBER LINE SLINGS

Fiber line slings are flexible and protect the finished material more than do wire rope sliings. But fiber line slings are not as strong as wire rope or chain slings. Also, fine line is more likely to be damaged by sharp edges on the material being hoisted than wire rope or chain slings.

CHAIN SLINGS

Chain slings are frequently used for hoisting heavy steel items, such as rails, pipes, beams, and angles. They are also handy for slinging hot loads and handling loads with sharp edges that might cut the wire rope.

USING WIRE ROPE AND FIBER LINE SLINGS

Three types of fiber line and wire rope slings commonly used for lifting a loud are the endless, single leg, and bridle slings.

An **endless sling,** usually referred to by the term **sling,** can be made by splicing the ends of a piece of fiber line or wire rope to form an endless loop. An endless sling is easy to handle and can be used as a **choker hitch** (fig. 13-30).

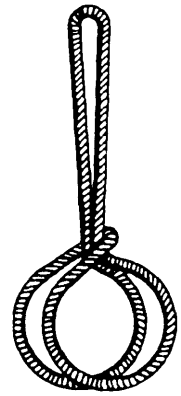

Figure 13-30.—Endless sling rigged as a choker hitch.

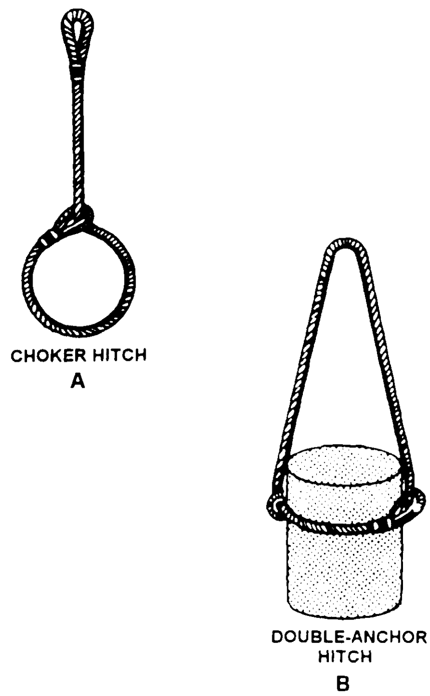

Figure 13-31.—Methods of using single-leg slings.

A **single-leg sling,** commonly referred to as a **strap,** can be made by forming a spliced eye in each end of a piece of fiber line or wire rope. Sometimes the ends of a piece oe wire rope are spliced into eyes around thimbles, and one eye is fastened to a hook with a shackle. With this arrangement, the shackle and hook are removable.

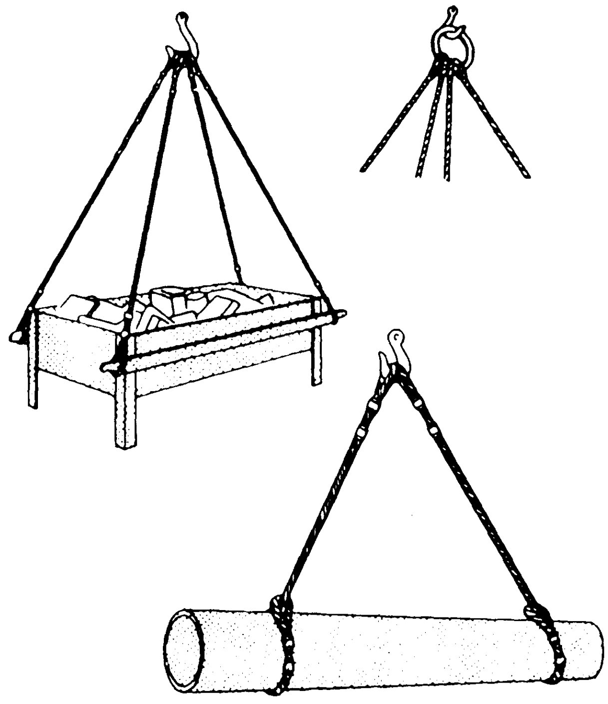

Figure 13-32.—Multi-legged bridle slings.

The single-leg sling may be used as a choker hitch (fig. 13-31, view A) in hoisting by passing one eye through the other eye and over the hoisting hook. The single-leg sling is also useful as a double-anchor hitch (fig. 13-31, view B). The double-anchor hitch works well for hoisting drums or other cylindrical objects where a sling must tighten itself under strain and lift by friction against the sides of the object.

Single-leg slings can be used to make various types of **bridles.** Three common uses of bridles are shown in figure 13-32. Either two or more single slings may be used for a given combination.

The bridle hitch provides excellent load stability when the load ia distributed equally among each sling leg. The load hook is directly over the center of gravity of the load, and the load is raised level. The use of bridle slings requires that the sling angles be carefully determined to ensure that the individual legs are not overloaded.

NOTE: It is wrong to conclude that a three- or four-leg bridle will safely lift a load equal to the safe load on one leg multiplied by the number of legs. This is because there is no way of knowing that each leg is carrying its share of the load.

With a four-legged bridle sling lifting a rigid load, it is possible for two of the legs to support practically the full load while the other two legs only balance it. COMSECOND/COMTHIRDNCB strongly recommend that the rated capacity for two-leg bridle slings listed in the COMSECOND/COMTHIRDNCBINST 11200.11 be used also as the safe working load for three- or four-leg bridle hitches.

When lifting heavy loads, you should ensure that the bottom of the sling legs is fastened to the load to prevent damage to the load. Many pieces of equipment have eyes fastened to them during the process of manufacture to aid in lifting. With some loads, though, fastening a hook to the eye on one end of each sling leg suffices to secure the sling to the load.

Use a protective pad when a fiber line or wire rope sling is exposed to sharp edges at the corners of a load. Pieces of wood or old rubber tires are fine for padding.

Sling Angle

When you are using slings, remember that the greater the angle from vertical, the greater the stress on the sling legs. This point is shown in figure 13-33.

The rated capacity of any sling depends on the size, the configuration, and the angles formed by the legs of the sling and the horizontal. A sling with two legs used to lift a 1,000-pound object will have 500 pounds of the load on each leg when the sling angle is 90 degrees. The load stress on each leg increases as the angle decreases; for example, if the sling angle is 30 degrees when lifting the same 1,000-pound object, the load is 1,000 pounds on each leg. Try to keep all sling angles greater than 45 degrees; sling angles approaching 30 degrees are considered extremely hazardous and must be avoided.

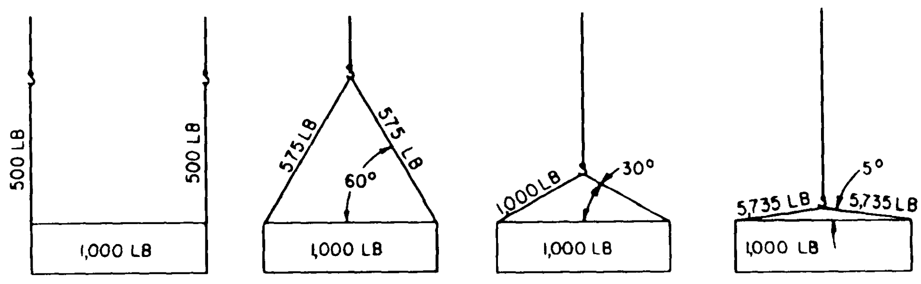

Figure 13-33.-Stress on slings at various vertical angles.

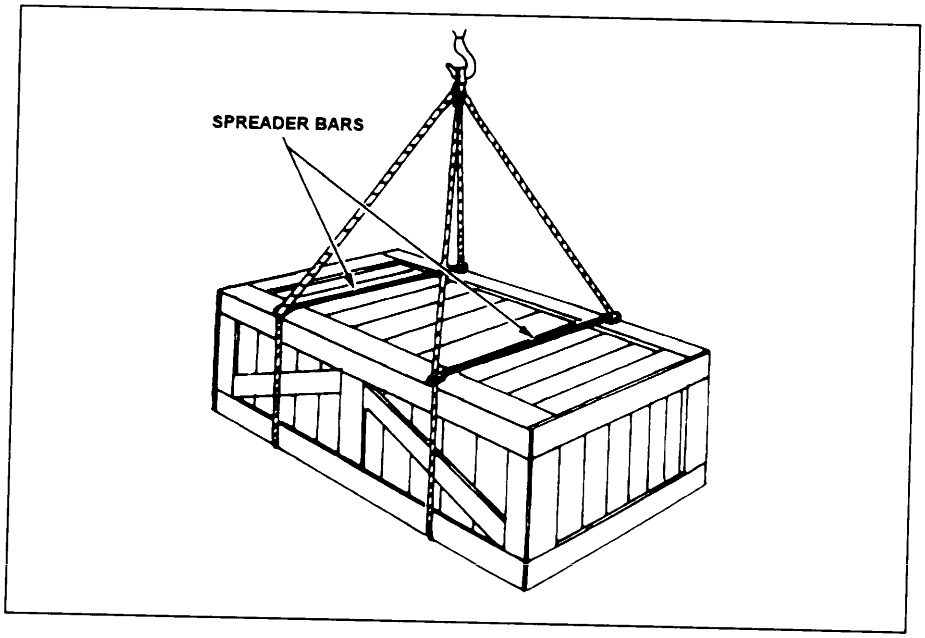

Figure 13-34.—Using spreader bars.

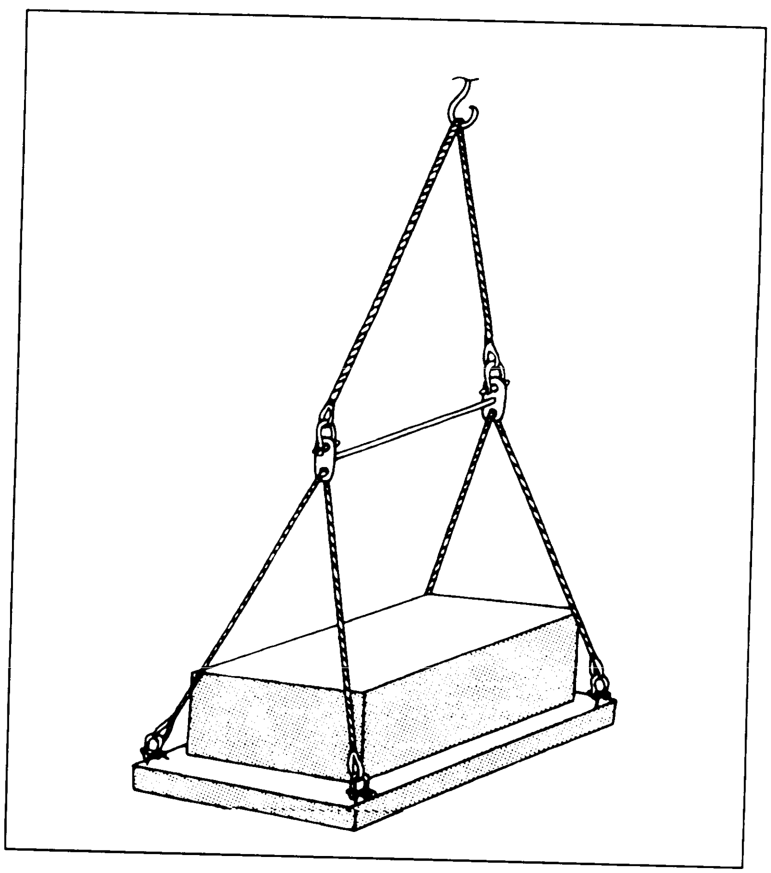

Figure 13-35.—Spreader bar used with an oversized load.

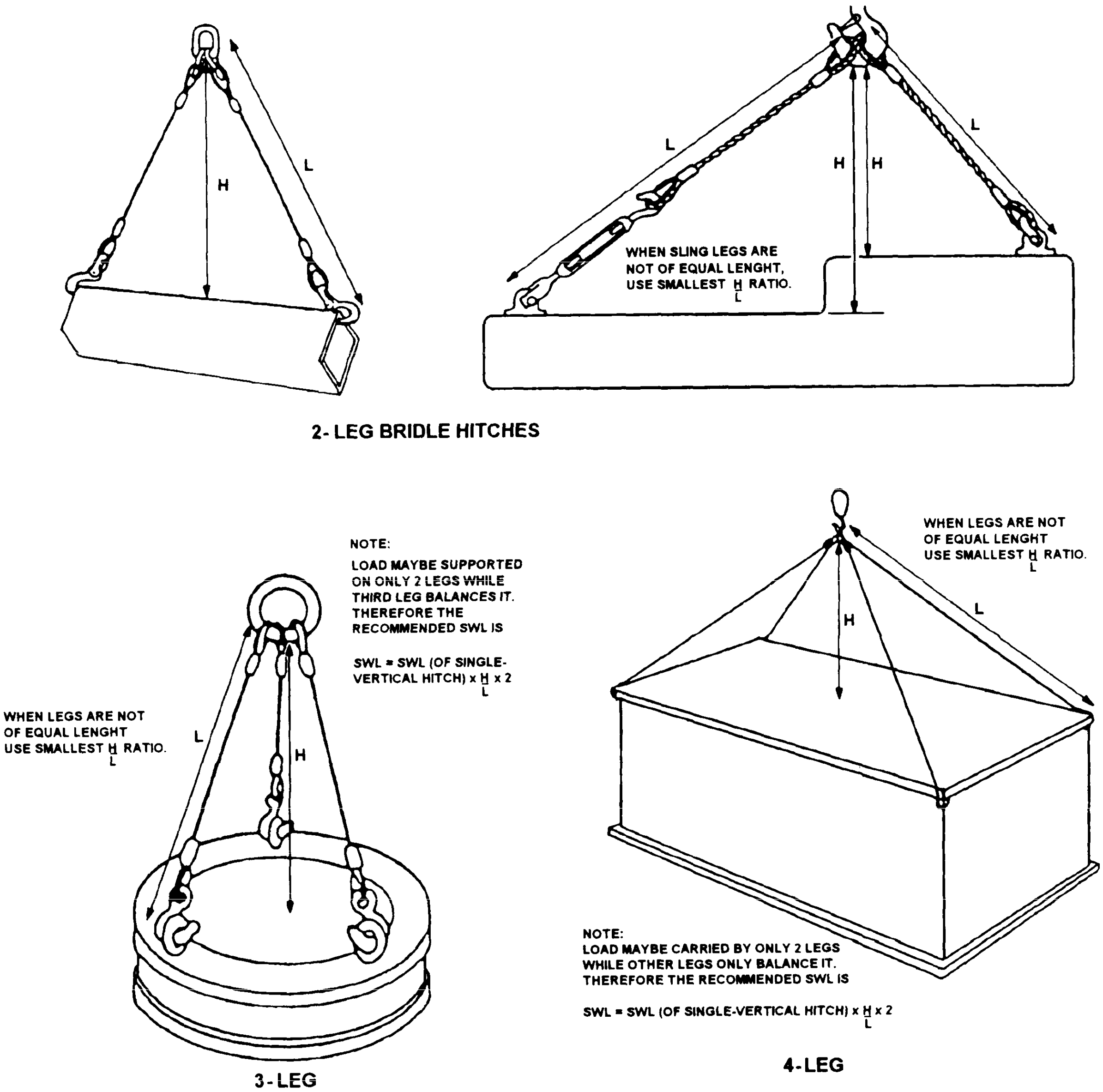

Figure 13-36.-Determination of bridle hitch sling capacity.

Spreaders Bars

In hoisting with slings, spreader bars are used to prevent crushing and damaging the load. Spreader bars are short bars, or pipes, with eyes fastened to each end. By setting spreader bars in the sling legs above the top of the load (fig. 13-34), you change the angle of the sling leg and avoid crushing the load particularly in the upper portion.

Spreader bars are also used in lifting long or oversized objects to control the sling angle, as shown in figure 13-35. When spreader bars are used, make sure you do not overload the end connection. A spreader bar has a rated capacity that is the same as hooks and shackles. A good rule of thumb is the thickness of the spreaders end connection should be the same as the thickness of the shackle pin.

Sling Safe Working Loads

Formulas for estimating the loads for most sling configurations have been developed. These formulas are based on the safe working load of the single-vertical hitch of a particular sling. The efficiencies of the end fittings used also have to be considered when determining the capacity of the combination.

The formula used to compute the safe working load (SWL) for a **bridle hitch** with two, three, or four legs (fig. 13-36) is SWL (of single-vertical hitch) times H (Height) divided by L (Length) times 2 = SWL. When

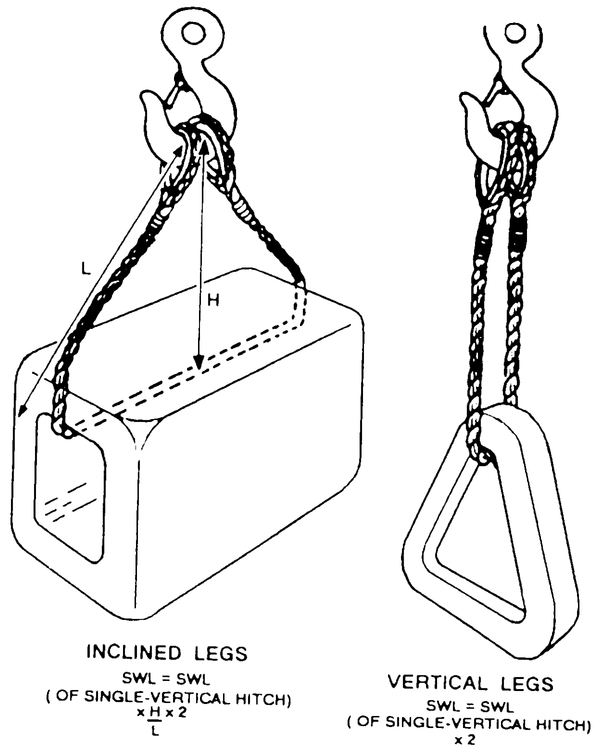

Figure 13-37.—Determination of single-basket hitch sling capacity.

the sling legs are not of equal length, use the smallest H/L measurement. This formula is for a two-leg bridle hitch, but it is strongly recommended that it also be used for the three- and four-leg hitches.

NOTE: Do NOT forget it is wrong to assume that a three- or four-leg hitch can safely lift a load equal to the safe load on one leg multiplied by the number of legs.

Other formulas are as follows:

Single-basket hitch (fig. 13-37): For vertical legs, SWL = SWL (of single-vertical hitch) x 2.

For inclined legs, SWL = SWL (of single-vertical hitch) x H divided by L x 4.

Double-basket hitch (fig. 13-38): For vertical legs, SWL = SWL (of single-vertical hitch) x 4.

For inclined legs, SWL = SWL (of single-vertical hitch) x H divided by L x 4.

Single-choker hitch (fig. 13-39): For sling angles of 45 degrees or more, SWL = SWL (of single-vertical hitch) x 3/4 or .75.

Sling angles of less than 45 degrees are not recommended; however, if they are used, the formula is SWL = SWL (of single-vertical hitch) x A/B.

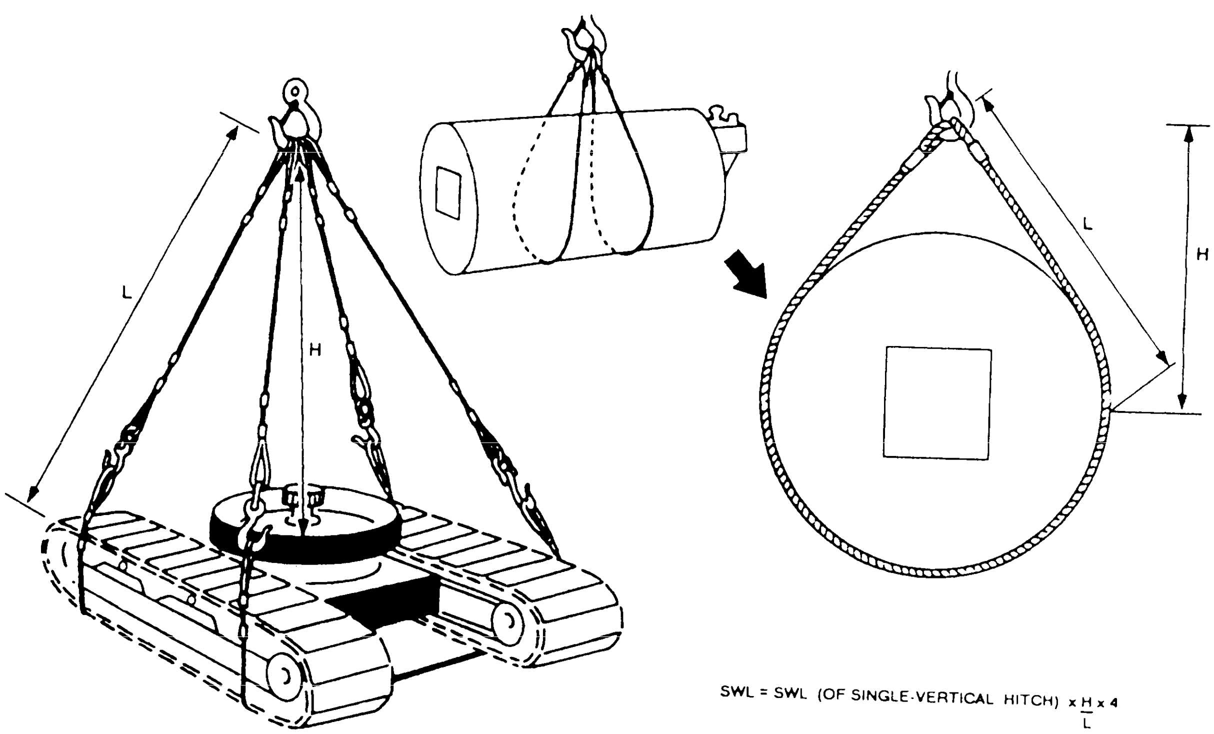

Figure 13-38.-Determination of double-basket hitch sling capacity.

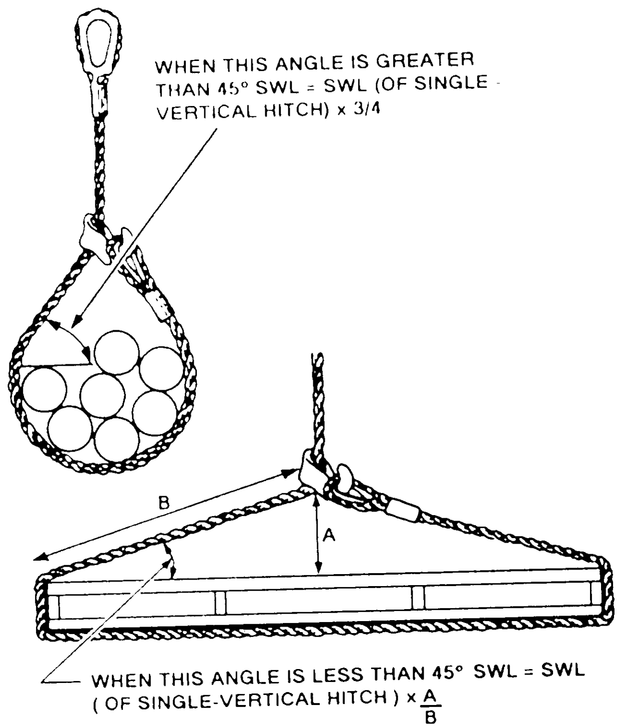

Figure 13-39.—Determination of single-choker hitch sling

Double-choker hitch (fig. 13-40): For sling angle of 45 degrees or more, SWL = SWL (of single-vertical hitch) x 3 divided by 4 x H divided by L x 2.

Sling angles of less than 45 degrees, SWL = SWL (of single-vertical hitch) x A divided by B x H divided by L x 2.

Sling Inspection

All slings must be visually inspected for obvious unsafe conditions before each use. A determination to remove slings from service requires experience and good judgment, especially when evaluating the remaining strength in a sling after allowing for normal wear. The safety of the sling depends primarily upon the remaining strength. Wire rope slings must be immediately removed from service if any of the following conditions are present:

- Six randomly distributed broken wires in one rope lay or three broken wires in one strand in one lay

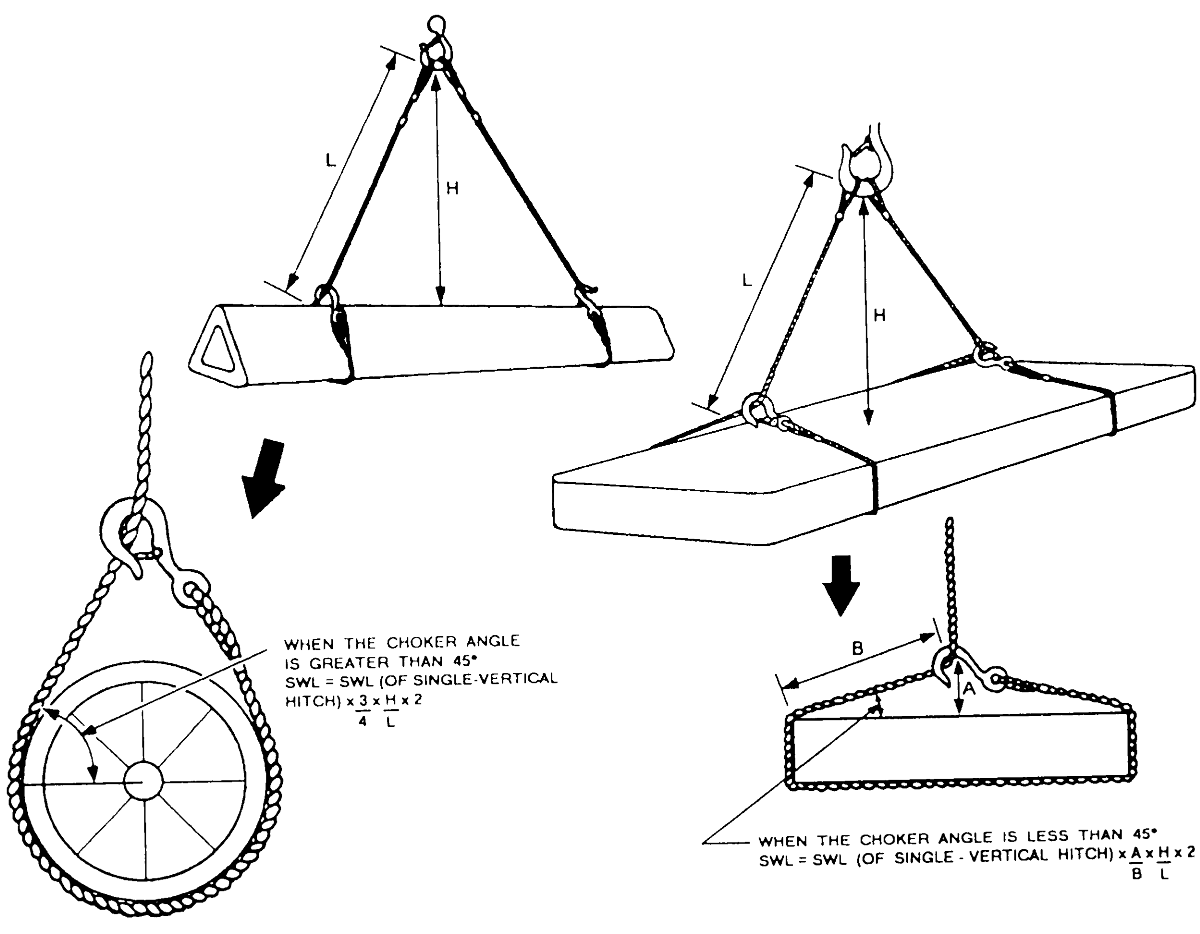

Figure 13-40.—Determination of double-choker hitch sling capacity.

- Wear or scraping on one third of the original diameter of outside individual wires

- Kinking, crushing, bird caging, or any other damage resulting in distortion of the wire rope structure

- Evidence of heat damage

- End attachments that arc cracked, deformed, or worn

- Hooks that have an obviously abnormal (usually 15 percent from the original specification) throat opening, measured at the narrowest point or twisted more than 10 degrees from the plane of the unbent hook

- Corrosion of the wire rope sling or end attachments

To avoid confusion and to eliminate doubt, you must not downgrade slings to a lower rated capcity. A sling must be removed from service if it cannot safely lift the load capacity for which it is rated. Slings and hooks removed from service must be destroyed by cutting before disposal. This ensures inadvertent use by another unit.

When a leg on a multiple-leg bridle sling is unsafe, you only have to destroy the damaged or unsafe leg(s). Units that have the capability may fabricate replacement legs in the field, provided the wire rope replacement is in compliance with specifications. The NCF has a hydraulic swaging and splicing kit in the battalion Table of Allowance (TOA). The kit, 80092, contains the tools and equipment necessary to fabricate 3/8- through 5/8-inch sizes of wire rope slings. Before use, all fabricated slings must be proof-tested as outlined in the COMSECOND/COMTHIRDNCBINST 11200.11.

Spreader bars, shackles, hooks, and so forth, must also be visually inspected before each usc for obvious damage or deformation.

Check fiber line slings for signs of deterioration, caused by exposure to the weather. See whether any of the fibers have been broken or cut by sharp-edged objects.

Proof Testing Slings

All field fabricated slings terminated by mechanical splices, sockets, and pressed and swaged terminals must be proof-loaded before placing the sling in initial service.

The COMSECOND/COMTHIRDNCBINST 11200.11 has rated capacity charts enclosed for numerous wire rope classifications. You must know the diameter, rope construction, type core, grade, and splice on the wire rope sling before referring to the charts. The charts will give you the vertical-rated capacity for the sling. The test weight for single-leg bridle slings and endless slings is the vertical-rated capacity (V. R. C.) multiplied by two (V.R.C. x 2 = sling test weight).

The test load for multiple-leg bridle slings must be applied to the individual legs and must be two times the vertical-rated capacity of a single-leg sling of the same size, grade, and wire rope construction. When slings and rigging are broken out of the TOA for field use, they must be proof-tested and tagged before being returned to CTR for storage.

Records

A card file system, containing a record of each sling in the unit's inventory, is established and maintained by the crane crew supervisor. Proof Test/Inspection Sheets (fig. 13-41) are used to document tests made on all items of weight-lifting slings, spreader bars, hooks, shackles, and so forth. These records are permanent and contain the following entries at a minimum:

1. Sling identification number (unit location and two-digit number with Alfa designation for each wire rope component)
2. Sling length
3. Cable body diameter (inches) and specifications
4. Type of splice
5. Rated capacity
6. Proof test weight
7. Date of proof test
8. Signature of proof test director

All the slings must have a permanently affixed, near the sling eye, durable identification tag containing the following information:

1. Rated capacity (in tons) (vert. SWL)
2. Rated capacity (in tons) (45-degree SWL)
3. Identification number

Spreader bars, shackles, and hooks must have the rated capacities and SWL permanent]y stenciled or stamped on them. OSHA identification tugs can be acquired at no cost from COMTHIRDNCB DET, Port Hueneme, California, or COMSECONDNCB DET, GulfPort, Mississippi. Metal dog tags are authorized providing the required information is stamped onto the tags.

WIRE ROPE SLING PROOF TEST/INSPECTION RECORD

Card ____ of ____

____ DATE

____ SLING I.D. NO.

Specification: ____
Length: ____
Cable body diameter: ____
Type splice: ____
Rated capacity (lbs): ____
* Proof test weight (lbs): ____
* Date of proof test: ____ Proof test director sig: ____
Date of inspection: ____ Crane Supv inspector sig: ____
Date of inspection: ____ Crane Supv inspector sig: ____
Date of inspection: ____ Crane Supv inspector sig: ____

REMARKS:

* Applies only to field fabricated slings.

Figure 13-41.—Proof Test/Inspection Sheet.

Storage

Wire rope slings and associated hardware must be stored either in coils or on reels, hung in the rigging loft, or laid on racks indoors to protect them from corrosive weather and other types of damage, such as kinking or being backed over. Slings are not to be left on the crane at the end of the workday.

MECHANICAL, ADVANTAGE

The push or pull a human can exert depends on the weight and strength of that individual. To move any load heavier than the amount you can physically move, a mechanical advantage must be used to multiply your power. The most commonly used mechanical devices are block and tackle, chain hoist, and winches.

BLOCK AND TACKLE

A **block** (fig. 13-42) consists of one or more sheaves fitted in a wood or metal frame supported by a shackle

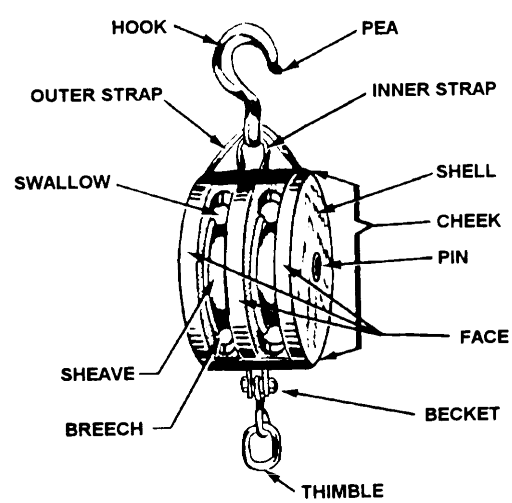

Figure 13-42.—Parts of a fiber line block.

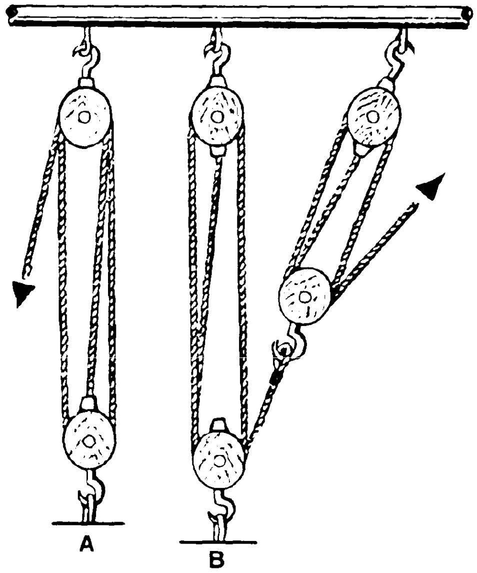

Figure 13-43.—A. Simple tackle; B. Compound tackle.

inserted in the strap of the block. A **tackle** (fig. 13-43) is an assembly of blocks and lines used to gain a mechanical advantage in lifting and pulling.

In a tackle assembly, the line is reeved over the sheaves of blocks. The two types of tackle systems are **simple** and **compound.** A simple tackle system is an assembly of blocks in which a single line is used (fig. 13-43, view A). A compound tackle system is an assembly of blocks in which more than one line is used (fig. 13-43, view B).

Various terms used with a tackle, as shown in figure 13-44, are as follows:

- The **fall** is either a wire rope or a fiber line reeved through a pair of blocks to form a tackle.
- The **hauling part** of the fall leads from the block upon which the power is exerted. The **standing part** is the end which is attached to a becket.
- The **movable** (or **running) block** of a tackle is the block attached to a fixed objector support. When a tackle is being used, the movable block moves and the fixed block remains stationary.
- **"Two blocked"** means that both blocks of a tackle are as close together as they will go. You may also hear this term called **block and block.**
- To **"overhaul"** means to lengthen a tackle by pulling the two blocks apart.

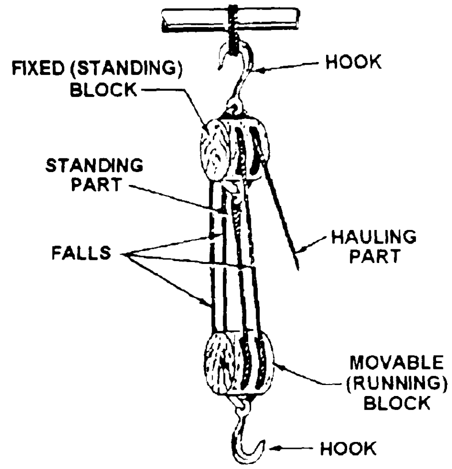

Figure 13-44.—Parts of a tackle.

- To **"round in"** means to bring the blocks of a tackle toward each other, usually without a load on the tackle (opposite of overhaul).

The block(s) in a tackle assembly change(s) the direction of pull, provide(s) mechanical advantage, or both. The name and location of the key parts of a fiber line block, as shown in figure 13-42, are as follows:

- The **frame** (or **shell),** made of wood or metal, houses the sheaves.
- The **sheave** is around, grooved wheel over which the line runs. Usually the blocks will have one, two, three, or four sheaves. Some blocks will have up to eleven sheaves.
- The **cheeks** are the solid sides of the frame or shell.
- The **pin** is a metal axle that the sheave turns on. It runs from cheek to cheek through the middle of the sheave.
- The **becket** is a metal loop, formed at one or both ends of a block; the standing part of the line is fastened to the becket.
- The **straps** hold the block together and support the pin on which the sheaves rotate.
- The **shallow** is the opening in the block through which the line passes.
- The **breech** is the part of the block opposite the swallow.

Blocks are constructed for use with fiber line or wire rope. Wire rope blocks are heavily constructed and have large sheaves with deep grooves. Fiber line blocks are generally not as heavily constructed as wire rope blocks and have smaller sheaves with shallow, wide grooves. A large sheave is needed with wire rope to prevent sharp bending. Because fiber line is more flexible and pliable, it does not require sheaves as large as that required for wire rope of the same size.

Blocks, fitted with one, two, three, or four sheaves, are often referred to as single, double, triple, and quadruple blocks. Blocks are fitted with a number of attachments, such as hooks, shackles, eyes, and rings. Figure 13-45 shows two metal framed, heavy-duty blocks. Block A is designed for manila line, and block B is for wire rope.

Block to Line Ratio

The size of a fiber line block is designated by the length in inches of the shell or cheek. The size of a standard wire rope block is controlled by the diameter of the rope. With nonstandard and special-purpose wire rope blocks, the size is found by measuring the diameter of one of its sheaves in inches.

Use care in selecting the proper size line or wire for the block to be used. If a fiber line is reeved onto a tackle whose sheaves are below a certain minimum diameter, the line becomes distorted that causes unnecessary wear. A wire rope too large for a sheave tends to be pinched that damages the sheave. Also, the wire will be damaged because of too short a radius of bend. A wire rope too small for a sheave lacks the necessary bearing surface, puts the strain on only a few strands, and shortens the life of the wire.

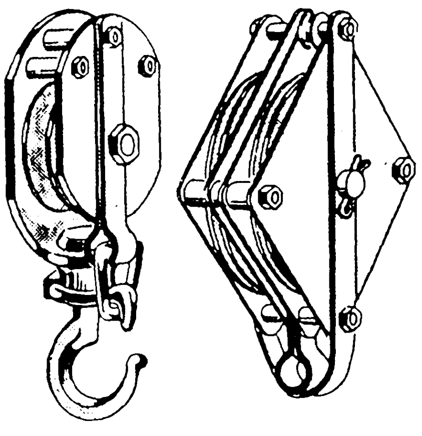

Figure 13-45.-Heavy-duty blocks.

With fiber line, the length of the block used should be about three times the circumference of the line. However, an inch or so either way does not matter too much; for example, a 3-inch line maybe reeved onto an 8-inch block with no ill effects. As a rule, you are more likely to know the block size than the sheave diameter. However, the sheave diameter should be about twice the size of the circumference of the line used.

Wire rope manufacturers issue tables that give the proper sheave diameters used with the various types and sizes of wire rope they manufacture. In the absence of these, a rough rule of thumb is that the sheave diameter should be about 20 times the diameter of the wire. Remember with wire rope, it is the **diameter,** rather than circumference, and this rule refers to the diameter of the sheave, rather than to the size of the block, as with line.

Block Safety

Safety items when using block and tackle are as follows:

- Always stress **safety** when hoisting and moving heavy objects around personnel with block and tackle.

- Always check the condition of blocks and sheaves before using them on a job to make sure they are in safe working order. See that the blocks are properly greased. Also, make sure that the line and sheave are the right size for the job.

- Remember that sheaves or drums which have become worn, chipped, or corrugated must not be used, because they will injure the line. Always find out whether you have enough mechanical advantage in the amount of blocks to make the load as easy to handle as possible.

- You must NOT use wire rope in sheaves and blocks designed for fiber line. They are not strong enough for that type of service, and the wire rope will not properly fit the sheaves grooves. Likewise, sheaves and blocks built for wire rope should NEVER be used for fiber line.

CHAIN HOISTS

Chain hoists provide a convenient and efficient method for hoisting by hand under particular circumstances. The chief advantages of chain hoists are that the load can remain stationary without requiring attention and that the hoist can be operated by one man to raise loads weighing several tons. The slow lifting travel of a chain hoist permits small movements, accurate adjustment of height, and gentle handling of loads. A ratchet handle pull hoist is used for short, horizontal pulls on heavy objects. Chain hoists differ widely in their mechanical advantage, depending upon their rated capacity.

Three general types of chain hoists for vertical operation are the spur gear hoist, the differential chain hoist, and the screw gear hoist.

The spur gear hoist (fig. 13-46, view A) is the most satisfactory for ordinary operations. This type of hoist is about 85 percent efficient. The differential chain hoist (fig. 13-46, view B) is only about 35 percent efficient and is satisfactory for occasional use and light loads. The screw gear hoist is about 50 percent efficient and is satisfactory where less frequent use of the hoist is required.

Chain hoists arc usually stamped with their load capacities on the shell of the upper block. Chain hoists are constructed with their lower hook as the weakest part of the assembly. This is done as a precaution, so the lower hook will be overloaded before the chain hoist is overloaded. The lower hook will start to spread under load, indicating the approaching overload limit. Under ordinary circumstances the pull, exerted on a chain hoist by one or two people, will not overload the hoist.

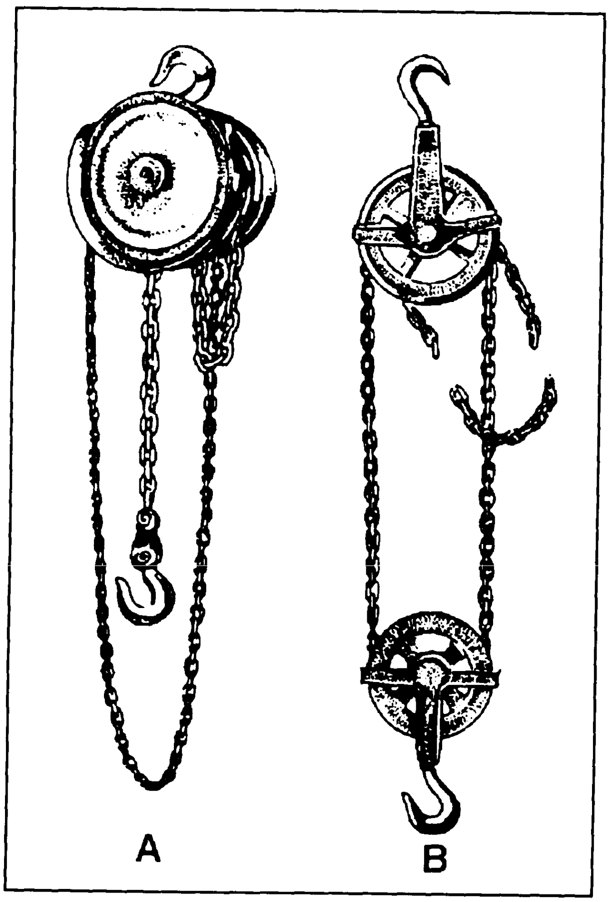

Figure 13-46.-A. Spur gear chain hoist; B. Differential chain hoist.

Chain hoists should be inspected before each use. Any evidence of spreading of the hook or excessive wear is sufficient cause to require replacement of the hook. If the links of the chain are distorted, it indicates that the chain hoist has been heavily overloaded and probably unsafe for further use. Under such circumstances the chain hoist should be condemned. Before using any permanently mounted chain hoists, you should ensure that the annual certification is current.

WINCHES

Vehicular-mounted winches and engine-driven winches are sometimes used in conjunction with tackles for hoisting. When placing a power winch to operate hoisting equipment, you must consider two points. First, you must consider the angle with the ground that the hoisting line makes at the drum of the hoist. This angle is sometimes referred to as **ground angle,** as shown in figure 13-47. The second point to consider is the **fleet angle** of the hoisting line winding on the drum, as shown

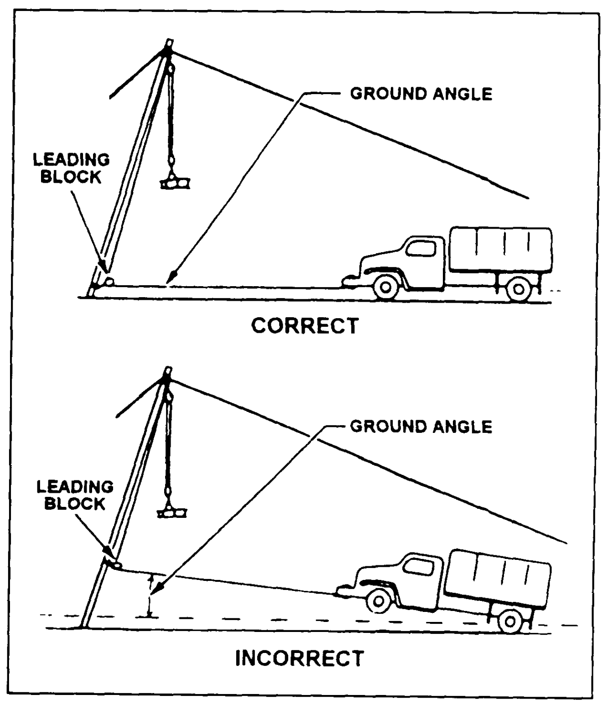

Figure 13-47.—Vehicle winch used for hoisting.

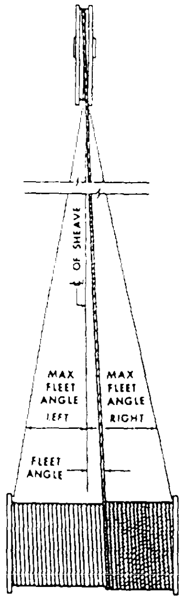

Figure 13-48.—Fleet angle of winch.

in figure 13-48. The distance from the drum to the sheave is the controlling factor in the fleet angle.

When you are using vehicle-mounted winches, the vehicle should be placed in a position which permits the operator to watch the load being hoisted. A winch is most effective when the pull is exerted on the bare drum of the winch. When a winch is rated at capacity, the rating applies only as the first layer of cable is wound onto the drum. The winch capacity is reduced as each layer of cable is wound onto the drum because of the change in leverage, resulting from the increased diameter of the drum. The capacity of the winch maybe reduced by as much as 50 percent when the last layer is being wound onto the drum.

Ground Angle

If the hoisting line leaves the drum at an angle upward from the ground, the resulting pull on the winch will tend to lift it off the ground. In this case, a leading block must be placed in the system at some distance from the drum to change the direction of the hoisting line to a horizontal or downward pull. The hoisting line should be overwound or underwound on the drum as may be necessary to avoid a reverse bend.

Fleet Angle

The drum of the winch is placed so that a line from the last block passing through the center of the drum is at right angles to the axis of the drum. The angle between this line and the hoisting line as it winds on the drum is call the fleet angle. As the hoisting line is wound in on the drum, it moves from one flange to the other, so the fleet angle changes during the hoisting process. The fleet angle should not be permitted to exceed 2 degrees and should be kept below this if possible. A 1 1/2-degree maximum angle is satisfactory and will be obtained if the distance from the drum to the first sheave is 40 inches for each inch from the center of the drum flange. The wider the drum of the hoist, the greater the lead distance must be in placing the winch.

RIGGING SAFE OPERATING PROCEDURES

All personnel involved with the use of rigging gear should be thoroughly instructed and trained to comply with the following practices:

1. Wire rope slings must not be used with loads that exceed the rated capacities outlined in enclosure (2) of the COMSECOND/COMTHIRDNCBINST 11200.11. Slings not included in the enclosure must be used only according to the manufacturer's recommendation.

2. Determine the weight of a load before attempting any lift.

3. Select a sling with sufficient capacity rating.

4. Examine all hardware, equipment, tackle, and slings before using them and destroy all defective components.

5. Use the proper hitch.

6. Guide loads with a tag line when practical.

7. When using multiple-leg slings, select the longest sling practical to reduce the stress on the individual sling legs.

8. Attach the sling securely to the load.

9. Pad or protect any sharp corners or edges the sling may come in contact with to prevent chaffing.

10. Keep the slings free of kinks, loops, or twists.

11. Keep hands and fingers from between the sling and the load.

12. To avoid placing shock on the loading slings, you should start the lift slowly.

13. Keep the slings well lubricated to prevent corrosion.

14. Do not pull the slings from under a load when the load is resting on the slings; block the load up to remove the slings.

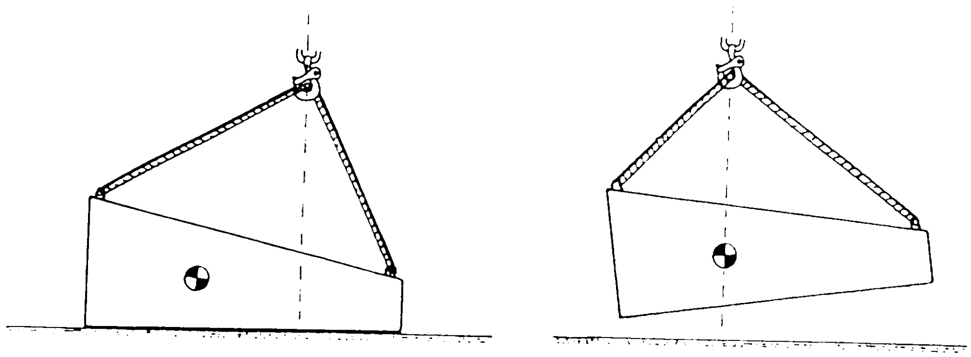

Figure 13-49.—Load shifting when Lifted.

15. Do not shorten a sling by knotting or using wire rope clips.

16. Do not inspect wire rope slings by passing bare hands over the rope. Broken wires, if present, may cause serious injuries. When practical, leather palm gloves should be worn when working with wire rope slings.

17. Center of balance. Stability of the load is important in the rigging process. A stable load is a load in which the center of balance of the load is directly below the hook, as shown in figure 13-49. When a load is suspended, it will always shift to that position below the hook. To rig a stable load, establish the center of balance (C/B). Once you have done this, simply swing the hook over the C/B and select the length of sling needed from the hook to the lifting point of the load.

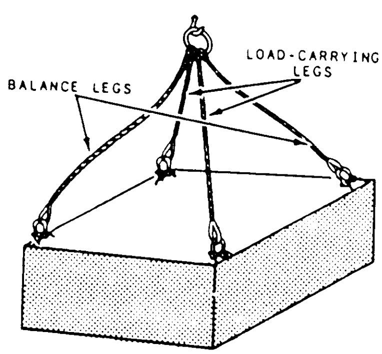

Figure 13-50.—Multi-legged bridle sling lifting a load.

18. When using a multi-legged bridle sling, do not forget it is wrong to assume that a three- or four-leg hitch will safely lift a load equal to the safe load on one leg multiplied by the number of legs. With a four-legged bridle sling lifting a rigid load, it is possible for two of the legs to support practically the full load while the other two only balance it (fig. 13-50).

NOTE: If all the legs of a multi-legged sling are not required, secure the remaining legs out of the way, as shown in figure 13-51.

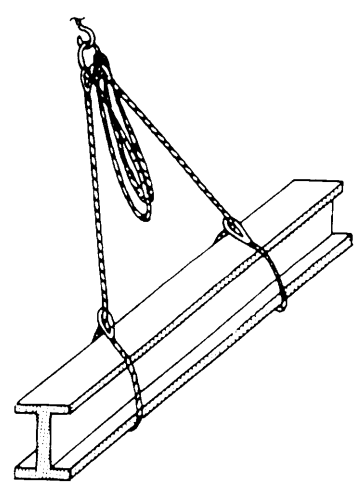

Figure 13-51.—Secure sling legs that are not used.